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THIRTY-SIXTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

BOSTON:
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THE STATE BOARD OF PUBLICATION.

MEMBERS OF THE BOARD.

1904.

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JULIAN A. MEAD, M.D.,	of Watertown.
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Secretary.
SAMUEL W. ABBOTT, M.D.
(Died Oct. 22, 1904.)

Engineer.
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Pathologist.
THEOBALD SMITH, M.D.

Chief Analyst of Food and Drugs
ALBERT E. LEACH, S.B.

Chemist.
H. W. CLARK.

Consulting Chemist.
THOMAS M. DROWN, M.D., LL.D.
(Died Nov. 16, 1904.)

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GENERAL REPORT.

The following report covers the work of the State Board of Health for the year ended Sept. 30, 1904. In the field of water supply and disposal of sewage, it covers the work performed during the year ended Dec. 31, 1904; and in that of production of diphtheria antitoxin and of laboratory diagnosis, only that done during the six months ended Sept. 30, 1904, the preceding six months' work having been reported upon in the report of the Board for the year 1903. It is intended in future to report the work done by all of the departments up to a common date, namely, September 30.

As in other years, a condensed account of the work performed is given in the first part, paged in Roman numerals, and fuller details are presented in the second part, paged in Arabic figures.

In 1904 the Board comprised the following members: —

HENRY P. WALCOTT, *Chairman.*

JAMES W. HULL.
CHARLES H. PORTER.
JULIAN A. MEAD.
HIRAM F. MILLS.
JOHN W. BARTOL.
GERARD C. TOBEY.

On Oct. 22, 1904, Dr. Samuel W. Abbott, secretary of the Board, died at his home in Newton. The following tribute to his memory was spread upon the records of the Board: —

Samuel Warren Abbott, M.D., was appointed health officer of the State Board of Health, Lunacy and Charity on Dec. 2, 1882. Upon the re-establishment of the Board of Health in 1886 he was elected secretary and executive officer of the Board. Throughout all these years, and until his death on Oct. 22, 1904, he was the able, devoted and untiring officer of a service to which he gave, with enthusiasm, the best years of his life. His capacities in the preparation and discussion of vital statistics were everywhere acknowledged by the masters of the subject, and there was no department of public hygiene which had so great an attraction for him, but he neglected none of the essentials in the administration of the laws for the protection and promotion of the public health.

He gave his early years to the perilous service of his country in time of war, and spent his later years in an equally determined struggle for the safety of the lives of his fellow men.

On Nov. 16, 1904, occurred the death of Dr. Thomas M. Drown, consulting chemist of the Board, and at the regular meeting of the Board on December 1 the following tribute was presented and spread upon the records: —

Professor Thomas Messenger Drown was selected by this Board, in 1887, as the analytical chemist of the highest repute to improve known methods of analysis for determining the character of the substances present in water which may have an injurious effect upon human health, and to take charge of analyses for determining the amount of such substances in the drinking waters of the State. In the important work which the Board conducted for many years he determined the methods of analysis to be used, and taught the Board and its agents the proper interpretation of the results. He had direction and very intimate oversight of the chemical work of the Board in the original investigations upon the purification of sewage by intermittent filtration, and upon its clarification by chemical precipitation.

After becoming president of Lehigh University he continued through life the highly valued adviser of the Board in the important questions involving chemical knowledge which have been presented to it for solution, and also continued as consulting chemist of its laboratories. He appreciated the importance to the community of the work which this Board was endeavoring to perform, and entered into his part of it with an earnestness and devotion that supported and encouraged every one associated with him.

His great knowledge, his appreciation of its limitations, his clear thinking, his justness, his kindness, his sweetness rendered work with him a delight, and have contributed ennobling characteristics to the work of the Board.

On Dec. 9, 1904, at a special meeting of the Board, Dr. Charles Harrington of Boston was elected secretary, and immediately entered upon the duties of the office. During the interval between the death of Dr. Abbott and the election of Dr. Harrington, the duties of the office were performed by Dr. John W. Bartol, a member of the Board.

GENERAL HEALTH OF THE STATE IN 1904.

The number of deaths in the State in 1904 was 48,482, which was equivalent to a death-rate of 15.76 per 1,000 upon an estimated population of 3,076,083. This is less than that of any year since 1848.

The mean death-rate of the four years 1901, 1902, 1903 and 1904 was 16.26, which was much less than that of any four successive years since the beginning of registration in 1842.

The following figures are presented for the ten years ended with 1904: —

Massachusetts.

YEARS.	Population.*	Deaths.	Death-rates.	YEARS.	Population.*	Deaths.	Death-rates.
1895, . . .	2,500,183	47,540	19.01	1900, . . .	2,805,346	51,156	18.24
1896, . . .	2,558,443	49,381	19.30	1901, . . .	2,870,710	48,275	16.82
1897, . . .	2,618,051	47,419	18.11	1902, . . .	2,937,600	47,491	16.17
1898, . . .	2,679,049	46,761	17.46	1903, . . .	3,006,040	49,054	16.32
1899, . . .	2,741,470	47,710	17.40	1904, . . .	3,076,083	48,482	15.76

* Population estimated for intercensal years.

INFECTIOUS DISEASES.

The death-rate from the principal infectious diseases in 1904 was generally less than that of the previous year. There was an increase in the number of deaths from consumption, cancer and cerebro-spinal meningitis, and a decrease in the deaths from smallpox, diphtheria, scarlet fever, typhoid fever, measles, cholera infantum, dysentery, whooping-cough and pneumonia.

The deaths and death-rates from each of the foregoing diseases in the past five years are shown in the following table: —

Deaths and Death-rates from Certain Diseases in Massachusetts, 1900-1904.

	1900.		1901.		1902.		1903.		1904.	
	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.
Smallpox, ...	3	.011	97	.34	284	.97	22	.07	9	.03
Diphtheria and croup, ...	1,475	5.26	1,166	4.06	873	2.97	869	2.89	699	2.27
Scarlet fever, ...	391	1.39	385	1.34	313	1.07	510	1.70	138	.45
Typhoid fever, ...	632	2.25	561	1.95	538	1.83	527	1.75	463	1.51
Measles, ...	330	1.18	173	.60	333	1.13	247	.82	160	.52
Cholera infantum, ...	2,393	8.53	2,705	9.43	3,157	10.75	2,469	8.21	2,297	7.47
Consumption, ...	5,199	18.53	5,033	17.54	4,685	15.95	4,531	15.07	4,874	15.84
Dysentery, ...	257	.92	223	.78	193	.66	188	.63	184	.60
Whooping-cough, ...	337	1.20	210	.73	337	1.15	519	1.73	117	.38
Pneumonia, ...	5,282	18.83	4,772	16.62	4,583	15.60	5,190	17.27	5,100	16.58
Cancer, ...	1,998	7.12	2,080	7.25	2,141	7.29	2,243	7.46	2,421	7.87
Cerebro-spinal meningitis, . .	198	.71	177	.62	165	.56	156	.52	165	.54

In the following table a balance is presented between the deaths from the principal infectious diseases in the two years 1903 and 1904, by which it appears that the sum of the deaths from these twelve causes in 1904 was less by 844 than those of 1903 from the same causes: —

Deaths from Certain Infectious Diseases in 1903 and 1904.

DISEASES.	1903.	1904.	Increase.	Decrease.
Smallpox, ...	22	9	-	13
Diphtheria and croup, ...	869	699		170
Scarlet fever, ...	510	138	-	372
Typhoid fever, ...	527	463	-	64
Measles, ...	247	160	-	87
Cholera infantum, ...	2,469	2,297	-	172
Consumption, ...	4,531	4,874	343	-
Dysentery, ...	188	184	-	4
Whooping-cough, ...	519	117	-	402
Pneumonia, ...	5,190	5,100	-	90
Cancer, ...	2,243	2,421	178	-
Cerebro-spinal meningitis, ...	156	165	9	-
Totals, ...	17,471	16,627	530	1,374

Infant Mortality.

The unusually low rate of infant mortality which prevailed during the three years 1901, 1902 and 1903 was even less during the year 1904, it being 133.6 for the latter year, as compared with 139.5 for 1903, 140.4 for 1902 and 137.2 for 1901.

The total number of births which occurred during the year ended June 30, 1904, was 74,791, and the total deaths under one during the year ended Dec. 31, 1904, were 9,992.

For the sake of accuracy the death-rate of infants under one year old is obtained by comparing the deaths of such infants occurring in a year with the mean number of infants under one living throughout a year, and this number must "lie between the annual number of births and that number diminished by the deaths under one. It would be nearer the latter than the former number on account of the excess of deaths in the first months of life" (Dr. Farr). In the following table the births in the first line are those which occurred between July 1, 1894, and June 30, 1895, inclusive, and so on through the table, the births in the last line being those for the year ended June 30, 1904.

The deaths under one in the same table are those of the calendar years ended Dec. 31, 1895, 1896, etc. The births during these ten years were 719,683, and the deaths under one year were 106,412, which is equivalent to an infant mortality-rate of 147.9 per 1,000 births for the decade. The last half of the period shows a substantial gain over the first half, since the infantile death-rate in the last five years was 141.8 per 1,000 births, as compared with 154.1 in the first five years.

Infant Mortality, Massachusetts: 1895–1904, Ten Years.

YEARS.	Births in Year ending June 30.	Deaths under One Year.	Death-rate under One Year per 1,000 Births.	YEARS.	Births in Year ending June 30.	Deaths under One Year.	Death-rate under One Year per 1,000 Births.
1895, . .	66,746	10,564	158.2	1900, . .	72,430	11,500	159.0
1896, . .	70,167	11,765	167.7	1901, . .	72,559	9,952	137.2
1897, . .	72,578	10,751	148.1	1902, . .	71,770	10,075	140.4
1898, . .	73,868	11,012	149.1	1903, . .	73,618	10,269	139.5
1899, . .	71,156	10,532	148.0	1904, . .	74,791	9,992	133.6

Total births in ten years ended June 30, 1904, 719,683.
Total deaths under one in ten years ended Dec. 31, 1904, 106,412.
Mean infantile death-rate, 147.9 per 1,000 births.

Smallpox.

During the years 1901–03, smallpox became epidemic to an unusual degree, but, owing to the vigorous and painstaking measures employed, in the year 1904 it assumed practically the conditions which prevailed in the two years immediately preceding those of the epidemic. The fatality from this disease was 9 per cent. in 1904 and 3.3 per cent. in 1903. The fatality in 1902, when the epidemic was at its height, was 11.9 per cent.

The total number of cases reported to this Board during the year 1904 was 100, and the deaths from this cause were 9. Of this number, 54 cases were those of males, with 7 deaths, and 46 were of females, with 2 deaths.

In the four years 1901–04, 3,600 cases had been reported to the State Board of Health, with 403 deaths, making a fatality of 11.2 per cent. In 1899 there were 105 cases reported, with 14 deaths, and in 1900, 104 cases, with 3 deaths; the fatality for these years being, respectively, 13.3 per cent. and 2.9 per cent.

The largest number of cases occurred during the month of September, 46 being reported for that month. Only 1 case was reported in April, and none during the months of November and December.

The following table shows the prevalence of the disease by months during the year 1904: —

	Cases.	Deaths.		Cases.	Deaths.
January,	5	1	July,	3	–
February,	5	–	August,	24	5
March,	3	1	September,	46	2
April,	1	–	October,	3	–
May,	7	–	November,	–	–
June,	3	–	December,	–	–

Of the 100 cases reported to the Board, the largest number, 61, occurred in North Adams. The following table shows the distribution of this disease among the cities and towns of the State, together with the number of deaths in each: —

	Reported Cases.	Deaths.		Reported Cases.	Deaths.
North Adams,	61	5	Adams,	3	1
Lawrence,	10	–	Monroe,	2	–
Lowell,	5	1	Beverly,	1	–
Leominster,	5	–	Gardner,	1	–
Pittsfield,	4	–	Milford,	1	–
Lee,	4	1	Totals,	100	9
Fitchburg,	3	1			

The following summary presents the number of reported cases and deaths in each year for the twenty-two years 1883–1904: —

Summary of Several Years, 1883–1904.

Years.	Cases.	Deaths.	Years.	Cases.	Deaths.
1883,	21	5	1895,	1	–
1884,	9	3	1896,	5	–
1885,	32	19	1897,	18	4
1886,	2	–	1898,	12	–
1887,	13	3	1899,	105	14
1888,	32	9	1900,	104	3
1889,	15	6	1901,	778	101
1890,	6	1	1902,	2,305	274
1891,	5	3	1903,	417	19*
1892,	19	2	1904,	100	9
1893,	45	9			
1894,	185	33	Totals,	4,229	517

* Four of these deaths, which occurred in the first days of January, 1903, were those of cases reported in December, 1902, and in reckoning the fatality of cases should be classed with the deaths of 1902.

The total number of reported cases in the twenty-two years was 4,229, and the deaths of these were 517, or 12.2 per cent.

The following table presents the data obtained from the returns received since and including 1888. The returns made previous to that date did not contain information of a sufficiently definite character to be included in this summary.

Smallpox in Massachusetts by Ages, and with Reference to Vaccination, 1888–1904.

Periods.	Vaccinated.		Unvaccinated.		Unknown.		Total.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
0–1 year,	5	–	179	45	2	–	186	45
1–5 years,	36	–	485	56	4	1	525	57
5–10 years,	36	–	267	8	9	–	312	8
10–15 years,	49	–	132	4	2	–	183	4
15–20 years,	95	3	253	17	6	2	354	22
20–30 years,	450	29	570	79	21	5	1,041	113
30–40 years,	501	43	278	55	7	1	786	99
40–50 years,	312	30	130	34	8	–	450	64
Over 50 years,	211	38	64	17	3	1	278	56
Age unknown,	14	–	12	5	10	–	36	5
Totals,	1,710	143	2,369	320	72	10	4,151	473

Following "Health of Towns," on the last pages of this report, may be found a record of visits made to cities and towns by the medical inspector for the purpose of investigating certain cases suspected of being smallpox.

Consumption.

The total number of deaths from this cause registered in 1904 was 4,874. While this was an increase of 343 deaths over the number of deaths occurring from this disease in 1903, and 189 more than occurred from the same disease in 1902, the death-rate from this cause was less than that of any year of record, except that of the previous year (1903).

The following figures present the deaths and death-rates, by ten-year periods, during the half century 1851–1900, and for the single years 1901, 1902, 1903 and 1904: —

Deaths and Death-rates from Consumption in Massachusetts, 1851–1904.

PERIODS.	Deaths.	Death-rates per 10,000.	PERIODS.	Deaths.	Death-rates per 10,000.
1851–60, ...	45,252	39.9	1901, ...	5,033	17.5
1861–70, ...	45,913	34.9	1902, ...	4,685	15.9
1871–80, ...	54,039	32.7	1903, ...	4,531	15.1
1881–90, ...	58,303	29.2	1904, ...	4,874	15.8
1891–1900, . . .	54,374	21.4			

Typhoid Fever.

The following table presents the deaths and death-rates of these cities from this cause during the four years 1901–1904: —

Deaths and Death-rates from Typhoid Fever in the Cities of Massachusetts, 1901–1904.

CITIES.	Deaths from Typhoid Fever.	Death-rates per 10,000.	CITIES.	Deaths from Typhoid Fever.	Death-rates per 10,000.
North Adams, . .	39	3.6	Brockton, . . .	26	1.5
New Bedford, . .	87	3.3	Beverly, . . .	9	1.5
Newburyport, . .	19	3.3	Melrose, . . .	8	1.5
Pittsfield, . . .	26	2.9	Worcester, . . .	67	1.3
Salem, ...	41	2.8	Somerville, . . .	35	1.3
Chelsea, ...	37	2.6	Everett, ...	15	1.3
Waltham, . . .	25	2.5	Cambridge, . . .	47	1.2
Malden, ...	34	2.4	Holyoke, . . .	24	1.2
Lawrence, . . .	62	2.3	Fitchburg, . . .	16	1.2
Boston, ...	517	2.2	Medford, . . .	9	1.1
Springfield, . . .	56	2.1	Northampton, . .	9	1.1
Lowell, ...	79	2.0	Quincy, ...	10	1.0
Fall River, . . .	81	1.8	Newton, ...	14	0.9
Lynn, ...	51	1.8	Marlborough, . .	4	0.8
Haverhill, . . .	28	1.8			
Gloucester, . . .	18	1.8	Total, . . .	1,539	–
Taunton, . . .	23	1.7			
Woburn, . . .	10	1.7			
Chicopee, . . .	13	1.6	Mean annual death-rate, . . .	–	1.9*

* Calculated from estimated mean annual population of the foregoing cities for the four years 1901-04 of 2,008,553.

By the foregoing table it appears that the death-rate from this cause during the four years 1901–04 was 1.9 per 10,000. By comparing this rate with the following condensed summary from the report of 1900 it can be seen that a decided and continuous improvement is taking place.

Death-rates from Typhoid Fever per 10,000, 1871-1904, Massachusetts.

1871–75,	8.2	1891–95,	3.4
1876–80,	4.2	1896–1900,	2.6
1881–85,	4.1	1901–04,	1.9
1886–90,	4.6		

For the entire State the death-rates from this cause in 1901, 1902, 1903 and 1904 were, respectively, 1.95, 1.83, 1.75 and 1.75 per 10,000 inhabitants.

The highest death-rates from this cause among the cities appear to have occurred in North Adams (3.6), New Bedford (3.3) and Newburyport (3.3); and the lowest occurred in Quincy (1), Newton (.9) and Marlborough (.8). Marlborough reported only 4 deaths from this cause in the four years.

Diphtheria.

The following table shows the deaths and death-rates from diphtheria by five-year periods from 1876 to 1900 and for the single years 1901, 1902, 1903 and 1904: —

Deaths and Death-rates from Diphtheria per 10,000, 1876–1904, Massachusetts.

YEARS.	Deaths.	Death-rates.	YEARS.	Deaths.	Death-rates.
1876–80,	13,676	15.8	1901,	1,166	4.1
1881–85,	8,944	9.5	1902,	873	3.0
1886–90,	8,857	8.4	1903,	869	2.9
1891–95,	7,652	6.4	1904,	699	2.3
1896–1900,	6,331	4.7			

Further and more definite information relative to diphtheria may be found in that portion of the report which relates to the production and distribution of antitoxin.

Other Preventable Diseases.

The following table presents the deaths and death-rates from measles, scarlet fever, dysentery, cholera infantum and whooping-cough, for the period of thirty-five years, 1866–1900, and for the four years 1901, 1902, 1903 and 1904: —

Deaths and Death-rates in Massachusetts per 10,000 Living from Certain Infectious Diseases by Five-year Periods, 1866-1900, and for 1901-04.

	MEASLES.		SCARLET FEVER.		DYSENTERY.		CHOLERA INFANTUM.		WHOOPING-COUGH.	
	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.
1866-70, . .	1,081	1.6	4,670	6.8	3,244	4.7	6,943	10.1	1,481	2.1
1871-75, . .	1,133	1.4	6,782	8.6	2,191	2.8	12,453	15.8	1,561	2.0
1876-80, . .	742	0.9	3,517	4.1	2,366	2.7	9,054	10.5	1,493	1.7
1881-85, . .	1,007	1.1	2,504	2.7	1,601	1.7	9,894	10.5	1,213	1.3
1886-90, . .	1,089	1.0	1,810	1.7	1,276	1.2	10,904	10.3	1,421	1.3
1891-95, . .	815	0.7	2,857	2.4	1,083	0.9	13,426	11.2	1,445	1.2
1896-1900, . .	948	0.7	1,358	1.0	1,434	1.1	11,865	8.9	1,465	1.1
1901, . . .	173	0.6	385	1.3	223	0.8	2,705	9.4	210	0.7
1902, . . .	333	1.1	313	1.1	193	0.7	3,157	10.7	337	1.1
1903, . . .	247	0.8	510	1.7	188	0.6	2,469	8.2	519	1.7
1904, . . .	160	0.5	138	0.5	184	0.6	2,297	7.5	117	0.4

The deaths from cerebro-spinal meningitis were 165, which were 9 more than occurred in the preceding year, and represented a death-rate of .5 per 10,000 living.

There were 2 deaths from glanders during the year and none from hydrophobia.

WATER SUPPLY AND SEWERAGE.

During the year, the Board received 125 applications for advice upon matters relating to water supply, sewerage and sewage disposal, — about the same number as in the previous year. The number includes also those cases in which the specific approval of plans of water supply and sewerage systems, or of the taking of lands for these purposes, is required by special acts of the Legislature, or votes of city or town governments. Of the 125 applications received, 74 related to water supply, 12 to sources of ice supply, 30 to sewerage, drainage and sewage-disposal systems, and 9 to miscellaneous matters, including the prevention of pollution of streams and tidal waters.

Examination of Water Supplies.

A public water supply was introduced during the year in the town of Ashfield, and at the end of the year, 172 of the 353 cities and towns in the State were provided with public water supplies. These 172 cities and towns contain approximately 92 per cent. of the population of the State. All of the cities and towns of the State having a population, according to the census of 1900, in excess of 3,500 are now provided with public water supplies, except the towns of Barnstable, Blackstone, Chelmsford, Dartmouth, Dudley, Pepperell and Tewksbury.

Many of the sources of public water supply were inspected during the year by the engineer of the Board or his assistants, and the waters of 210 sources were examined at regular intervals by means of chemical analyses. Microscopical and bacterial analyses also have been made in some cases. The results of the examinations of water supplies are presented on pages 109 to 176 of this report. The tables of analyses made during the year, as usually given in previous reports, are omitted, and the results of examinations made during the past five years have been summarized, and are presented in general tables so arranged as to afford a means of comparing the various waters as to their sanitary condition and the various properties usually considered in determining the quality of a drinking water. The usual tables of water supply statistics are presented on pages 183 to 192.

Rules and Regulations for preventing the Pollution and securing the Sanitary Protection of Waters used as Sources of Public Water Supply.

In response to the petitions of the authorities of the cities of Worcester, Northampton and Springfield, and the towns of Plymouth, Greenfield, Easthampton, Wakefield, Randolph and Holbrook, the Board has established rules and regulations for preventing the pollution and securing the sanitary protection of the ponds and streams used by those municipalities as sources of public water supply. The rules and regulations are similar to those which have been adopted by the Board in previous years for the protection of the waters of other cities and towns.

Experiments upon the Application of Salts of Copper to Ponds and Reservoirs, to destroy Growths of Organisms.

One of the most serious annoyances to which the users of water drawn from ponds and reservoirs are subjected is the disagreeable taste and odor by which the water of many of these sources is at times affected, — an annoyance which has been sufficient in some cases to lead to the abandonment of the source of supply.

The objectionable tastes and odors of pond and reservoir waters, which are often attributed to decaying fish and other causes, are, in practically all cases which have been brought to the attention of the Board, caused by the presence of organisms, in some cases of kinds which attach themselves to the sides and bottom of the reservoir, but in the majority of cases of those kinds which live in suspension in the water. Early in 1903, Dr. George T. Moore, algologist of the United States Department of Agriculture, brought to the attention of the Board the results of investigations which he had made, indicating that the microscopic organisms which are the chief cause of objectionable tastes and odors in the waters of ponds and reservoirs could be destroyed by applying sulphate of copper, or blue vitriol, to the water in very small quantities; and information was also submitted tending to show that bacteria were also destroyed in water brought in contact with metallic copper. Experimental tests of the applicability of the use of sulphate of copper as a method of removing growths of organisms, and the objectionable conditions which they cause, as suggested by Dr. Moore, were begun at once. Salts of copper are nearly all soluble in water, and are regarded as poisonous when used in food preparations; it is obviously necessary, under the circumstances, that these substances should not be deposited in water used for drinking purposes until their probable effect upon the condition of the reservoir, and especially upon the health of those to whom the water is being supplied, has been definitely determined. Fortunately, a considerable number of ponds and reservoirs formerly used as sources of water supply, but now abandoned, were found to be available for experiment; and in the use of these reservoirs there was the advantage that their biological history had been observed during the period of their use as sources of water supply, and that these records were available for use in determining the changes resulting from a treatment such as that proposed.

Two of these sources were treated with copper sulphate in 1903, the quantities applied amounting to from 1 part in 1,500,000 to 1 part in 2,000,000 parts of water; and during 1904 further experiments have been carried on with these and other reservoirs. The application of copper sulphate has been made in all cases under the direction of Dr. Moore, and the effect of the treatment upon the chemical and biological condition of the water has been determined by analyses of samples collected before and after the treatment.

One of the matters of greatest importance in connection with the possible use of copper sulphate for the removal of growths of organisms from public water supplies is to determine what becomes of the copper deposited in the water, and many experiments have been made to determine its final disposition. Experiments are also being made to determine the effect of this form of treatment upon animal life of various kinds.

The results of some of the experiments and investigations so far as obtained tend to support the conclusions which had been reached when the matter was first brought to the attention of the Board as to the practicability of the copper treatment for the removal of growths of organisms and bacteria, but the results of other experiments conflict with some of these conclusions. Further study and experiment are necessary before the probable results of the use of copper in preventing objectionable conditions resulting from growths of organisms, or the probable effect of the use of this substance in public water supplies upon the public health, can be conclusively determined.

The Lawrence City Filter.

The Lawrence city filter, constructed for the purpose of purifying the sewage-polluted water of the Merrimack River and preventing the excessive death-rate from typhoid fever and other diseases resulting from the use of a polluted water supply, was constructed by the city under the advice of this Board in 1893. How successfully it has served its purpose is shown by the great reduction in the death-rate of the city in the years following the completion and use of the filter, as compared with the preceding years.

The filter was designed to be of sufficient capacity for the needs of the city at the time it was built; but the original design, which included a cover or roof to protect the filter in winter, was not carried out, and its operation has been greatly hampered and its capacity limited on account of the impracticability of maintaining its surface in proper condition in cold weather. In the winter of 1901–02, the consumption of water in the city was for a period of several days greater than the capacity of the filter; and for a period of many days in that winter the water stored in the distributing reservoir was very nearly exhausted. Early in the spring of 1902, the Board advised the city of the urgent need of covering the filter, thus relieving it from obstruction from ice and snow and freezing weather, and to provide as soon as practicable an additional filtering area; but the only action taken by the city authorities was to divide the filter into three parts, by means of walls, by which a very little improvement was made in the operation of the filter. The winter of 1902–03 being a very mild one, enough water was obtained for the supply of the city. Nothing was done in the summer season of 1903 toward enlarging the works for supplying filtered water to the city or pure drinking water from any other source, though in the month of December plans for a new filter were finally submitted to and approved by the Board. In the winter of 1903–04 the distributing reservoir again became very nearly exhausted, so that, if a large fire or an accident to the works had occurred, it would have been necessary to introduce the sewage-polluted water of the Merrimack River directly into the city's supply mains. During the past summer, also, nothing has been done by the city to avert the calamity of introducing the unfiltered Merrimack River water, from which the city has twice barely escaped. The responsibility for the present conditions appears to rest upon the city government, which, in spite of the warnings given, has not seen fit to make provision for protecting the lives and health of the people of the city from the danger to which they are now exposed.

Examination of Sewer Outlets and the Effect of Sewage Disposal.

The examinations of sewer outlets during the past year have been directed chiefly to the outlets into Boston harbor, and to investigations of the conditions of flats and tidal waters from which shellfish are taken for food.

On April 28, a communication was received from the city of New Bedford, requesting advice as to whether clams and quahaugs collected from the Acushnet River could safely be used for food; and in response to this request the Board examined the conditions of the flats and tidal waters about the city of New Bedford and the places from which shellfish were being collected, and caused numerous bacterial examinations to be made of the shellfish collected from the flats and waters about the city. The results of the investigations showed that the sewage from a part of the city of New Bedford was being discharged into New Bedford harbor through twenty-six sewer outlets, and that there were six sewer outlets discharging into Clark's Cove, an arm of the sea south of the city. The sewage of the town of Fairhaven, situated opposite New Bedford, is also discharged into New Bedford harbor. The great bulk of shellfish collected from the waters about New Bedford are taken from New Bedford harbor, and the observations made by the Board show that a large proportion were collected from the New Bedford side of the harbor, often within 400 feet of the shores in front of the sewer outlets. Numerous samples of quahaugs collected from all over the harbor have been analyzed by the Board, and a large proportion of them were found to show the presence of sewage bacteria. Shellfish are also collected all about the upper end of Clark's Cove, and examinations of samples from this locality have shown that a large percentage are affected by sewage.

Since it was evident, from these examinations and investigations, that shellfish taken from these localities were likely to injure the health of those who might use them for food, the Board deemed it necessary that the further taking of shellfish from these waters should be prevented; and therefore brought the matter to the attention of the Commissioners on Inland Fisheries and Game, and requested that commission, under the provisions of section 113 of chapter 91 of the Revised Laws, to prohibit the taking of shellfish from the waters of New Bedford harbor north of or inside of a line drawn from Fort Point in Fairhaven to a point on the easterly shore of Clark's Point one mile south of the most southerly sewer outlet in the city of New Bedford, or from the waters of Clark's Cove at any place within three-quarters of a mile of the outlet of any sewer of the city of New Bedford discharging into Clark's Cove; and a chart showing the areas from which the taking of shellfish was prohibited was sent to the commission.

Examination of Rivers.

A report on the rivers affected by sewage pollution which have been under observation during the year, together with a summary of the results of the various analyses showing the condition of the Blackstone and Merrimack rivers, will be found on pages 177 to 182.

The Neponset River.

The most serious sources of pollution of the Neponset River in Norwood and Walpole above the Great Meadows are caused by the wastes from the sewer of the town of Norwood and the wastes from a tannery, two paper mills and a gas works. Plans for the purification of the town sewage and the tannery wastes have been submitted to and approved by the Board; and during the past year notice has been given to the authorities of the town and the owners of the tannery to discontinue the discharge of unpurified sewage and wastes into the river after July 1, 1905.

Plans for the disposal of the wastes of three other works have been submitted for the approval of the Board, and the owners of other large works have notified the Board of their intention to present plans for the purification of their wastes at an early date. The quantities of water used in some of these works and seriously polluted in the various processes are very large, and it is essential that these waters should be returned to the stream, after purification, for the use of other owners below. Under these circumstances the problem of satisfactorily purifying these wastes is in many cases a serious one, requiring a careful study of the methods proposed, in order to secure satisfactory results.

Investigations upon the Purification of Sewage and Water at the Lawrence Experiment Station.

In sewage filtration, especial attention has been given during the past year to intermittent sand filters, which have been in operation for many years at the Lawrence Experiment Station. Efforts have been made during the year so to operate these filters that the organic matter which has accumulated upon the sand may be removed by bacterial action, and increased efficiency be thereby obtained.

This study has given rise to various other special lines of work on the varied character of organic matter stored in sewage filters and its degree of stability and resistance to bacterial oxidation; and in connection with this work, experiments have been made to determine the degree of acidity or alkalinity of the effluents of sewage filters of different kinds when they are effecting the highest degree of purification.

The investigations as to the operation of septic tanks and the efficiency of contact and the intermittent continuous filters have been continued as in the previous year, and the filters used in testing the results of these methods of sewage purification have been constructed of different materials and operated at various rates. Investigations have also been made as to the kinds of bacteria in sewage, and their functions in the process of sewage purification. A new method of determining the degree of turbidity in water, especially in the effluents from sewage filters, has been worked out at the experiment station during the year, this method giving a much better idea of the actual amount of mineral and organic matter present in the water as suspended matter or sediment than the method hitherto used.

The experiments upon the filtration of water have been continued as in previous years, special attention being given to the results obtainable by rapid filtration, aided by coagulants, and by double filtration, in order to determine the efficiency of such methods.

Investigations have been made during the year at the experiment station upon the bacterial examination of shellfish affected by sewage pollution, to determine the length of time the dangerous organisms may live in shellfish under various conditions, and the degree of heat necessary in cooking to destroy pathogenic bacteria. Much work has been done at the experiment station, as already indicated, in the study of the effect of copper sulphate and metallic copper upon microscopic organisms and bacteria.

The results of the experiments are presented on pages 195 to 295.

Food and Drug Inspection.

The work of the State Board of Health in the inspection of food and drugs during the year ended Sept. 30, 1904, will be found reported upon pages 297–345. This work was entrusted to the State Board of Health by a statute enacted in 1882 (chapter 263 of the Acts of that year), and has been conducted continuously under the supervision of the Board since that year.

Primarily the work is conducted as a system of inspection, the samples obtained for analysis being purchased in open market in the same manner as such articles are commonly purchased by the consumers. Provision is also made for the examination of articles of food or drugs under proper conditions, which are brought to the office for examination by citizens. This, however, does not include the examination of products intended for sale by dealers or manufacturers or producers, when such examination may be used for advertising purposes.

The number of samples of food and drugs examined by the analysts of the Board during the year ended Sept. 30, 1904, was 8,651, the total number for the whole period of work since 1883 being 157,356.

The number of prosecutions during the year was 62, and the whole number for the whole period of work was 1,788. The detailed account of the prosecutions was sent to the Legislature in January, 1905, and is also published in this report.

The inspection of liquors has included the examination, by the analysts of the Board, of samples sent in for analysis by police officers, or because of the supposed existence of harmful adulterants. During the year ending Dec. 31, 1904, 283 samples of liquor were sent in for analysis by chiefs of police and other officers, and, of the cases in which the liquor was sold in no-license towns and contained more than 1 per cent. of alcohol, a large proportion were prosecuted.

INVESTIGATION OF THE SANITARY CONDITIONS OF FACTORIES, WORKSHOPS AND OTHER PLACES OF EMPLOYMENT IN THE COMMONWEALTH.

The following resolve was enacted by the Legislature at the session of 1904: —

[CHAPTER 99, RESOLVES OF 1904.]

RESOLVE TO PROVIDE FOR AN INVESTIGATION AS TO SANITARY AND OTHER CONDITIONS AFFECTING THE HEALTH OR SAFETY OF EMPLOYEES IN FACTORIES AND OTHER ESTABLISHMENTS.

Resolved, That the state board of health, with such aid as it may require from the chief of the district police and the bureau of statistics of labor, is hereby directed to investigate the sanitary conditions of factories, workshops and other places of employment in the Commonwealth of Massachusetts, with respect to all conditions which may endanger the life and limb or be prejudicial to the health of the persons employed therein. The officers and employees of said board shall have power to enter and inspect all premises in use for industrial purposes and to obtain such information as may be necessary for carrying out the purposes of this resolve. The board may expend a sum not exceeding one thousand dollars in carrying out the provisions of this resolve, and is directed to report to the next general court on or before the fifteenth day of January next, and shall accompany its report with such recommendations as it deems advisable. [*Approved June 3, 1904.*]

Under the terms of this resolve, the following report was prepared for the Legislature of 1905, and was forwarded in due course: —

In the study of the relations of industrial conditions to health, it is very essential to success not to give more than due weight to the results of analysis of mortality returns, which, unless proper allowance is made for various important factors, may lead to very fallacious results. The complete dissociation of the influence of these factors is, in any extensive inquiry, quite beyond the range of possibility; but with due consideration of the differences existing in the conditions which attend different callings, many valuable inferences can be drawn. Due weight must be given to the fact that, while certain occupations are open only to the strong and intelligent, others are the refuge of the weak and ignorant. Some of the callings recognized as dangerous fail to attract the better element of the working classes, in spite of a high rate of wage; while others of the same class, conducted under proper hygienic supervision, may attract the same class in spite of a comparatively low rate. The extramural conditions also are of the highest importance, whatever be the nature of the calling. In the same line of work, those who are properly housed, fed and clothed, and whose mode of life is marked by temperance in all things which may influence health, will show a smaller percentage of sickness, a lower death-rate and a higher average age at death than those whose home surroundings are inferior or bad, and whose lives are marked by vicious excesses. Again, age is an important factor. In certain lines of industry that offer but a low wage, it is largely the very young, not yet arrived at full development, who respond to the call; and if the particular industry be one of those classed as dangerous, the inevitable result of non-observance or non-provision of necessary hygienic precautions is a high rate of morbidity and mortality and a low average age at death.

The callings which are most likely to exert an injurious influence on any class of persons are those conducted indoors, and especially those which involve exposure to poisonous substances of a gaseous nature and to irritating and poisonous dusts. In all of the industries which properly are regarded as dangerous, the operatives themselves are commonly very largely to blame for the harmful results generally recognized, because of their disregard of proper hygienic precautions which can easily be observed. It is a notorious fact, for example, that workers exposed to dust are generally disinclined to use respirators designed to prevent its inhalation, and are averse to the use of hoods and fans which are set in place for its proper removal, if it happens that these devices interfere in any degree with the supply of light; and that those whose hands come in contact with poisonous substances, such as lead and lead compounds, are commonly prone to neglect the simple precaution of cleansing their hands thoroughly before handling their noonday food. It is to be said, however, in justice to those who decline to use respirators, that most of these contrivances cause marked discomfort, becoming wet with the condensed aqueous vapor of the respired air, causing some difficulty in breathing and promoting local perspiration.

The subject of occupational hygiene being so very broad and complex, it is plain that, within the brief period allowed and within the limits of the appropriation made for such an extensive inquiry, definite results can be obtained only within very narrow bounds; and that the most useful results would follow an effort to investigate the conditions inseparable from or incident to a few of the more dangerous of the processes pertaining to some of the important trades and industries, and to localize the specific causes of ill-health among the operatives engaged therein.

Under existing laws, the district police have a definite line of sanitary work to perform in the inspection of the ordinary sanitary provisions which should exist in all factories, such as the condition of water-closets, ventilation, drainage, etc.; and hence it would appear that the broader duty of investigating the specially injurious conditions peculiar to the different lines of industry was the important and essential part of the work imposed upon the Board, and it was decided to confine the inquiry chiefly to a number of those industries involving exposure to dust and to other substances of a poisonous nature. This selection was influenced mainly by the fact that the inhalation of dust predisposes to the development of diseases of the lungs, especially of pulmonary consumption, and by the additional fact that this danger can be obviated in large part by the observance of precautionary measures.

That the leading causes of death in this and other countries are diseases of the lungs, is too well known to need more than passing mention. The sanitary authorities of all civilized countries view the enormous death-rate from consumption with grave concern; and the study of methods for its reduction is engaging widespread attention, not alone of the medical profession, but of thinkers in every walk of life. That industrial conditions are largely responsible for its spread has been recognized ever since the beginning of the systematic study of occupational hygiene, more than two centuries ago; and it has long been known that the disease is much more prevalent among the followers of certain callings which involve confinement in a dusty atmosphere than among those whose work involves no such exposure. Since the discovery of the specific cause of the disease in 1882, and the method of its dissemination from the sick to those who are susceptible, it has become more and more evident that, in confined spaces, the presence of consumptives is a menace to the health of their associates, even though the habit of indiscriminate spitting be not indulged in. The spitting consumptive is naturally a far greater menace, since his sputum contains the exciting cause of the disease in great numbers, and when dried and pulverized it becomes disseminated in the form of infectious dust. The inhalation of irritating dusts of various kinds leads to local changes in the mucous surfaces of the respiratory tract, and thus enables the specific germ to establish a foothold in the systems of those whose lowered vitality has made them susceptible to attack. It is obvious, therefore, that a due regard for the health of those exposed to industrial dusts demands that this source of danger should be reduced as much as possible by the application of all reasonable sanitary measures. Students of industrial hygiene are substantially agreed on the general proposition that there is scarcely a dangerous trade which cannot be made safe by the exercise of extreme care and attention to proper sanitary regulations.

In the beginning of this investigation it was hoped that valuable data might be secured from a study of the records of the State Sanatorium at Rutland. Examination showed, however, that of a large number of patients who had followed trades which commonly are classed as dangerous to health, no less than 46.35 per cent. belonged to families which had a tubercular history, one or more members having died of the disease. It is naturally impossible in these cases to determine whether the patient acquired the disease as an accident of his calling, or in consequence of daily contact with a sufferer at home.

A study of the causes of deaths reported from several of the industrial centres to the office of the Secretary of State has yielded certain facts which have an apparent value, and these will be found below in the consideration of some of the various trades which have been investigated.

In the report below, of observations made in the various establishments visited, on account of the fact that time and expense did not permit of anything like an investigation of the conditions obtaining in all of the plants of each industry within the Commonwealth, no names will be given, and thus no charge of invidious distinction can be laid.

In the investigation of the industries selected, some forty cities and towns were visited and more than one hundred factories were examined. These included cutlery and tool factories, stone-cutting establishments, cigar factories, shoe factories, cotton, woolen and silk mills, in all of which industries the evolution of dust is an incident of greater or less importance; rubber factories, white lead works and lead pipe works, in all of which the possibility of lead poisoning is one of the dangers to be considered; bakeries, laundries, curled-hair factories, straw shops, and miscellaneous others of lesser importance.

The Cutlery and Tool Industry.

In the manufacture of cutlery and tools, the most important of the processes from a hygienic point of view are those of wet and dry grinding and burnishing. In the operation of wet grinding, each operative reduces to their proper shape and size a certain number of pieces per day, using for the purpose large grindstones run by power. This process being completed, the articles are ground farther on other finer stones, or "whitened." Next, they are taken to the dry-grinding room, where they are farther subjected to the action of emery and corundum wheels, and finally they are polished on buffing wheels. In all of these processes, even in the wet grinding, a large amount of exceedingly irritating mineral and metallic dust is given off; and in properly equipped establishments provision is made for its speedy removal by means of hoods and exhaust fans or blowers. In five of the fifteen establishments visited there was a proper equipment of fans and but little dust; in three, the hoods had been partly or wholly removed, on account of interference with light; in one, the fans were mostly without hoods and the rest were inefficient; in three there were no fans whatever; and in the remainder there were fans which were only partly efficient. In one of the dry-grinding rooms a consumptive was employed, with no precautions whatever against possible contamination of the air by his dried expectorations.

The occupation of cutlery grinding is justly regarded as one of the most dangerous of callings. The average age of operatives at death is exceedingly low, and in establishments conducted without proper hygienic precautions, sound men are rare after a few years' work. The prevailing cause of death is consumption, which usually overtakes a susceptible worker so early that his period of usefulness does not extend much beyond five or six years, excepting in factories where the health of the workmen is properly safeguarded. Interviews with physicians having large practice among cutlery employees bear out these statements. One physician stated that nearly all who reach the age of forty die of tuberculosis, excepting those who succumb to some acute disease. Another, located in another industrial centre, has noticed a falling off in the incidence of the disease during the past ten years, due to the better care of the workmen and to improved conditions at the factories. Others state that consumption is far more common among grinders than among any other class with whom they have to deal. The death returns for the past five years from Northampton and Montague, two of the most important seats of the cutlery industry, offer some interesting facts. In Northampton the death-rate from tuberculosis for the entire male adult population for five years was 2.9 per thousand, while that for the cutlers was no less than 11.8 per thousand, or four times as great. In Montague the five-year rates for the two classes were, respectively, 2.6 and 8 per thousand.

From the investigations made, the conclusion must be drawn that in a certain proportion of the establishments visited exceedingly objectionable and injurious conditions obtain, and that these are susceptible of much improvement. The operation of wet grinding is carried on generally in basements and cellars, which are damp and dark. In dry grinding, the wheels should be so equipped with hoods and fans as to prevent careless operatives from interfering with these necessary safeguards.

The Stone-cutting and Stone-polishing Industry.

Like the cutlery industry, the operation of cutting and polishing stone indoors is attended by great risk to health. But four establishments of this class were visited, and in all but one there was much dust in the air, and a history of consumption as a leading disease. In this connection, certain facts communicated by the chief medical examiner of one of the largest fraternal benefit organizations are of interest. He states that the statistics of 30,000 deaths show that among the stone cutters there was 1 death from consumption to 2.5 from all other causes, while among carpenters the proportion was 1 to 10.

In this industry, as in the preceding, provisions for the prevention of a dusty atmosphere are called for.

The Tobacco Industry.

As representatives of the tobacco industry, 4 factories, employing from 75 to 900 men and women, were visited. In the operation of making cigars a great deal of dust arises, and in the three largest establishments visited the atmosphere was exceedingly bad from this cause and from overcrowding. In all three the sanitary arrangements were in most unsatisfactory condition. The habit of indiscriminate spitting was general, and it was noticed that many of the cigarmakers completed each cigar with the aid of saliva. The possibility of disseminating loathsome diseases through this practice needs no extended discussion. Perhaps it would be fair to say that it is uncertain how long the germs of certain diseases which might appear to be transmissible in this manner may retain their vitality in contact with moist tobacco, but the idea is sufficiently revolting on æsthetic grounds alone. An objectionable practice, which obtains very generally and which should be the subject of some regulation, is the sale of sweepings. In the operation of making cigars considerable tobacco in larger or smaller pieces falls to the floor. At intervals these are swept up, sifted, and sold as fillings for cheaper cigars. Where the habit of promiscuous spitting prevails, the tobacco thus recovered is likely to be contaminated to some extent with disease organisms which may exist in the secretions of the mouth.

In one smaller factory in the western part of the State the atmosphere was kept pure by means of mechanical ventilating appliances. There was no spitting, and the ends of the cigars were finished with the aid of gum tragacanth rather than with the workmen's saliva.

The Boot and Shoe Industry.

In investigating the boot and shoe industry, 30 different establishments of various sizes, located in 8 different cities and towns, were visited. The number of operatives in these establishments varied between 75 and 3,000. Nearly all of them were provided to some extent with blowers or exhaust fans for mechanical ventilation, but in many instances the apparatus was inadequate for the needs of the establishment. In most of them the sanitary provisions were fair; in some the closets were unexceptional; in some they were unpardonably foul.

In certain processes connected with the manufacture of shoes there is evolution of considerable dust; and this industry, therefore, may fairly be classed among the dusty trades.

A study of the returns of the causes of death from the cities of Lynn and Brockton during three years gives certain results which are in themselves of some interest as indicating the disease tendency of those engaged in shoe factories, and of still more interest for the purpose of comparison with similar returns from other cities where different industries are followed.

In the city of Brockton, of 167 deaths occurring among shoemakers, 42, or 25 per cent. of the whole, were due to pulmonary consumption; and of this number the proportion of those dying below the age of thirty years was 36 per cent. There were 61 deaths from consumption plus other diseases of the lungs, or 36.5 per cent. of the entire mortality.

In Lynn, during the same three years, of 297 deaths among shoemakers, 65, or 22 per cent., were due to consumption; and 95, or 32 per cent., were due to consumption plus other lung diseases. More than one-half (55.4 per cent.) of those who died from consumption had not yet attained their thirtieth year.

There was one condition which was very noticeable in a large proportion of the shoe factories visited, but by no means peculiar to this line of industry, and that was the habit of indiscriminate spitting. In some instances spittoons were provided, and these appeared to diminish the habit of spitting carelessly upon the floors; in some, spitting is forbidden; in others, it is not forbidden and spittoons are not supplied. In some of the larger establishments everything that can be provided for the health, comfort and happiness of the employees may be found; but in others there is room for very marked improvement.

The Paper Industry.

Nine establishments, engaged chiefly in the manufacture of writing paper and other papers of high quality, were visited. The operatives engaged in certain of the processes of paper making are exposed to considerable dust from rags used in the manufacture; those engaged in other departments are exposed more or less to wet; and those in still others are exposed to no industrial dangers whatever. The most important department of such a mill, from a sanitary standpoint, is the rag-sorting room. In most of the mills visited, provision exists for carrying away, by mechanical ventilation, the dust arising from the handling of the rags; in some, no provision whatever is made. On account of the nature of the raw material, it is generally thought that there is some risk of infection of those who handle the rags, and smallpox is everywhere looked upon as one of the most important possible dangers of the paper industry. It would appear, however, from facts obtainable, that cases of infection traceable to the handling of rags are not common. In some of the establishments, it is said, the rag sorters are seldom sick. In the establishments visited, the operatives had generally the appearance of health and strength. Whether the danger from smallpox is real or imaginary, there is already legislation which is pertinent; for section 138 of chapter 75 of the Revised Laws empowers local boards of health to compel the authorities of any factory to cause all of the workmen to be vaccinated. In certain of the establishments not only is no attention paid to causing the employees to be so protected, but those seeking employment are not asked if they ever have been vaccinated.

In the various paper mills visited, the habit of indiscriminate spitting was observed. The water-closets were, in the main, of the proper sort, and reasonably well looked after; the machinery was found to be well protected. In two rag-sorting rooms the atmosphere was exceedingly dusty, in spite of the presence of twenty-four-inch fans in active operation.

The Textile Industry.

The leading indoor occupation, that is to say, the one in which the largest number of persons is employed in factories in this Commonwealth, is the textile industry in its various branches. The proper investigation of so important an industry would require much more time and a much larger appropriation than were allowed for this entire inquiry.

It is a well-known fact that the dust arising in the various lines of textile work is exceedingly irritating to the respiratory passages, and that tuberculosis finds an enormous number of victims among the operatives. It is, however, a fact, which must not be slighted, that these industries are among the few that are open to persons of weak constitution and poor development. The work in the picking-room, carding-room, spinning-room and weaving-room is not of a kind that appeals to most vigorous men, who can do better, financially and otherwise, in other lines of usefulness.

A few establishments were visited, but our observations were not sufficient to warrant description or advice in regard to this important field of work. That careful study should be given to this industry is indicated by the following results of the study of the mortality due to consumption and other lung diseases among operatives in three mill towns. In one, no less than 36.5 per cent. of the operatives whose deaths were reported died from pulmonary consumption, and 50 per cent. died of consumption and other lung diseases. Nearly 50 per cent. of those who died from consumption were less than thirty years of age at the time of death.

In another, 28.7 per cent. of the decedent operatives died of consumption, and 35 per cent., of consumption plus other lung diseases; and of those dying of consumption, no less than 67.3 per cent. were less than thirty years of age.

In a third, 26.3 per cent. of the deaths among operatives were due to consumption, and 44 per cent., to consumption plus other lung diseases; and of those who died of consumption, no less than 52 per cent. were under thirty years of age.

The Rubber Industry.

In this industry we have to deal both with dust, some of which is both irritating and poisonous, and with noxious fumes. The most important dust is a compound of lead, against the inhalation of which respirators are commonly provided, and almost as commonly refused. Of the vapors which are given off in the various processes, some are nauseous but not directly harmful, and others, as naphtha and carbon disulphide fumes, exert an undoubted injurious influence on the nervous system. In one of the three large establishments visited there was much promiscuous spitting about the floors and into the waste products; in two there was no provision for ventilation except by the windows, although in one of these the room in which the lead compound was mixed with the other ingredients was ventilated by means of a blower. In one mill, which was conducted with proper regard for hygienic conditions, there was a history of cases of chronic lead poisoning; but in the others, one of which was far from sanitary in its general condition, no such evidence could be secured from those in charge.

The Lead Industry.

In the manufacture of white lead, lead pipe and sheet lead, the particular danger is that of chronic lead poisoning, due to the inhalation of dust and to the convey-ance of lead from the unwashed hands into the digestive system, largely through handling of food materials. Respirators and fan ventilation, and the observance of personal cleanliness, play a great part in reducing this danger. In one of the principal white lead factories, where about 100 men are employed, ventilation by blowers was observed to reduce the dust to a minimum. Respirators are provided, but the workmen will not use them. Occasional cases of lead poisoning are observed, but they can truly be attributed to the negligence of the victims themselves. In the other establishments visited, the hygienic conditions were good, but the employees were in great part careless as to especial danger to their health, incident to this occupation.

Other Industries.

Of the remaining lines of industry investigated, the number of establishments visited and available for examination proved to be so limited in number that deductions drawn from what was observed might not be warranted in the light of further investigation, and hence might be misleading; consequently, it seems best not to attempt to make present use of the facts observed.

Existing Legislation.

Most of the defects to which attention has been called are provided for already in existing laws; but it is to be said that these provisions are more or less scattered, and that in many instances the phraseology is so loose or obscure that they have little or no real value. For example, section 41 of chapter 104 of the Revised Laws, after providing for guarding belting, shafting, gearing and drums, disposes of the important subject of ventilation in the following words, "All factories shall be well ventilated and kept clean," but does not provide any standard by which the adequacy of the ventilation shall be measured. Section 51 of chapter 106 would appear to go somewhat farther, but it requires no extended examination to reveal its defects. It provides as follows: "A factory in which five or more persons and a workshop in which five or more women or young persons are employed shall, while work is carried on therein, be so ventilated that the air shall not become so impure as to be injurious to the health of the persons employed therein, and so that all gases, vapors, dust or other impurities injurious to health, which are generated in the course of the manufacturing process or handicraft carried on therein shall, so far as practicable, be rendered harmless;" but it stipulates nothing as to the processes which shall be followed in rendering these gases, vapors and other injurious impurities harmless, and it fails to establish a limit of permissible impurity, below which the air shall be regarded as possessing no deleterious properties. The next section of the same chapter reads as follows: "If, in a workshop or factory which is within the provisions of the preceding section, any process is carried on by which dust is caused which may be inhaled to an injurious extent by the persons employed therein, and it appears to an inspector of factories and public buildings that such inhalation would be substantially diminished without unreasonable expense by the use of a fan or by other mechanical means, such fan or other mechanical means, if he so directs, shall be provided, maintained and used." In this section there is nothing to indicate who shall be the judge of whether the dust is inhaled to an injurious extent; and, even though it be determined that the dust is so inhaled, there is no provision for mitigating the condition, unless it shall appear that the danger may be substantially diminished without unreasonable expense.

In its desire to safeguard the health of women and young persons employed in factories and workshops, the Legislature has provided for a proper interval for a midday meal; but a number of different industries are exempt from this requirement, as is shown below. Sections 37 and 38 of chapter 106, Revised Laws, read as follows: "Section 37. No woman or young person shall be employed for more than six hours at one time in a factory or workshop in which five or more such persons are employed without an interval of at least half an hour for a meal; but such person may be so employed for not more than six and one-half hours at one time if such employment ends not later than one o'clock in the afternoon and if he or she is then dismissed from the factory or workshop for the remainder of the day; or for not more than seven and one-half hours at one time if he or she is allowed sufficient opportunity for eating a lunch during the continuance of such employment and if such employment ends not later than two o'clock in the afternoon and he or she is then dismissed from the factory or workshop for the remainder of the day.

"Section 38. The provisions of the two preceding sections shall not apply to iron works, glass works, paper mills, letter press establishments, print works, bleaching works or dyeing works; and the chief of the district police, if it is proved to his satisfaction that in any other class of factories or workshops it is necessary, by reason of the continuous nature of the processes or of special circumstances affecting such class, to exempt it from the provisions of the two preceding sections and that such exemption can be made without injury to the health of the women or young persons affected thereby, may, with the approval of the governor, issue a certificate granting such exemption, public notice whereof shall, without expense to the commonwealth, be given in the manner directed by said chief"

Section 39 of the same chapter practically nullifies the provision, so far as the factories not specially exempted are concerned, since, if the person for whose benefit the provision is made chooses to work during the interval allowed for rest and food, she may do so, if a notice is posted forbidding her to work, and if she does so without the order, consent or knowledge of the employer or his agent, as will be seen: "Section 39. If a minor under the age of eighteen years or a woman shall, without the orders, consent or knowledge of the employer or if a superintendent, overseer or other agent of the employer, labor in a manufacturing or mechanical establishment, factory or workshop, according to the notice required by section twenty-four, and if a copy of such notice was posted in a conspicuous place in the room where such labor was performed with a rule of the establishment, factory or workshop forbidding such minor or woman to labor during such time, then neither the employer nor a superintendent, overseer or other agent of the employer shall be held responsible for such labor." In many of the establishments visited it was observed that those engaged in piece-work gave the shortest possible time to their midday meal, and took no time for rest or for a change of air, but returned as soon as possible to their labor. It is a matter of common knowledge that young persons, especially, suffer injury to health from unbroken confinement indoors and from hasty bolting of food. It would seem as though it might be a wise provision not only to provide that working people shall have a reasonable interval for rest and food, but that they shall be prevented by something more than posted regulations, which they may violate with impunity, from returning to work until the expiration of the interval.

While the condition of the closets in many of the factories was found not to be up to the standard which seems proper, it must be said that they were no worse than would probably be found in an examination of dwellings and business houses of all sorts. However that may be, the matter is already placed under the supervision and control of the district police by section 8 of chapter 108 of the Revised Laws, which requires the members of the inspection department of the district police to enforce all provisions of the laws relating to sanitary conditions of factories; and section 49 of chapter 106 empowers the inspectors of factories to bring to the notice of local boards of health any unsanitary condition of the water-closets, water supply, or any nuisance; and such boards are required to inquire into the subject and to enforce the laws relative thereto.

Recommendations.

In each of the industries which the Board has reported upon, namely, cutlery grinding, stone cutting and stone polishing, cigar making, boot and shoe making, rag sorting, the rubber industry and the lead industry, one or more establishments were found in which the proprietors had made reasonable provision for protecting the health of the operatives, while in others very little care was taken for their protection. We would recommend that it be the duty of the inspection department of the district police to require, so far as is reasonably practicable under the varying circumstances, as efficient protection to the health of the operatives in any occupation as is provided in that occupation where, within the Commonwealth, such protection is most efficient.

The desirability of a codification of all laws relating to industrial pursuits and to sanitation of factories and workshops after the manner of the British factory acts, of a more explicit phraseology, of the establishment of standards of ventilation efficiency, and of the enactment of some measure against spitting upon the floors of factories, workshops and other confined spaces, is respectfully suggested.

Routine Work of the Board.

Statistical Table for the Year ended Sept. 30, 1904.

Whole number of samples of food and drugs examined during the year,	8,651
Samples of milk examined (included in the foregoing),	4,997
Whole number of samples of food and drugs examined since beginning of work in 1883,	157,356
Whole number of samples of milk examined since beginning of work in 1883,	87,304
Number of prosecutions against offenders during the year,	62
Number of convictions during the year,	57
Amount of fines imposed during the year,	$1,509
Number of packages of antitoxin of 1,500 units each issued to cities and towns,*	22,255
Number of bacterial cultures made for the diagnosis of diphtheria in cities and towns,*	1,014

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* For the six months ended Sept. 30, 1904.

Number of examinations made for diagnosis of tuberculosis,*	494
Number of examinations of blood made for diagnosis of malarial infection,*	24
Number of examinations of blood made for the diagnosis of typhoid fever,*	204
Number of notices of cases of infectious diseases received and recorded under the provisions of chapter 75, section 52, Revised Laws,†	26,088
Number of postal-card returns of mortality for cities and towns received and recorded,†	2,111
Number of annual reports of cities and towns received under the provisions of chapter 75, section 12, Revised Laws,†‡	95

Force employed in general work of Board at central office, State House: —	
Secretary,	1
Medical inspector,	1
Clerks,	3
Total,	5

Force employed at central office, State House, Boston, for food and drug inspection, chemists and assistants,	2
At Amherst,	1
Inspectors,	3
Total,	6

Force employed at laboratory (Bussey Institution): —	
Pathologist,	1
Assistants,	6
Total,	7

UNDER THE PROVISIONS OF CHAPTER 375, ACTS OF 1888.

Applications for advice from cities, towns and others: —	
Relating to water supply,	74
Relating to ice supply,	12
Relating to sewerage and drainage,	30
Relating to pollution of streams,	6
Miscellaneous,	3
Total,	125

Number of samples of water, ice and sewage examined chemically and microscopically at the laboratory, Room 502, State House,	4,058
Number of samples of sewage, water and ice examined chemically and bacterially at the Lawrence Experiment Station,	2,179

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* For the six months ended Sept. 30, 1904. † For the calendar year 1904.

‡ Cities and towns having a population of more than 5,000 in each.

Number of samples of sand examined chemically at the Lawrence Experiment Station,	278
Number of samples of sand examined mechanically at the Lawrence Experiment Station,	134
Additional samples examined bacterially at the Lawrence Experiment Station,	5,060
Samples of water, ice, etc., examined for B. coli and sewage Streptococcus at the Lawrence Experiment Station,	4,065
Number of shellfish examined for B. coli and sewage Streptococcus,	968
Total number of samples examined,	16,742

Force employed at central office: —		
Chief engineer,	1	
Assistant engineers,	7	
Stenographers and clerks,	3	
Messenger,	1	
	—	12
At laboratory, Room 502, State House: —		
Chemist,	1	
Assistant chemists,	5	
Biologist,	1	
Stenographer,	1	
	—	8
At Lawrence Experiment Station: —		
Assistant chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	3	
	—	7
Total ordinary force,		27

The number of applications for advice under the provisions of the acts relating to water supply and sewerage, received since July, 1886, when these acts first went into operation, is as follows: —

1886,	8
1887,	22
1888,	28
1889,	38
1890,	23
1891,	53
1892,	56
1893,	51
1894,	53
1895,	52
1896,	65
1897,	59
1898,	75
1899,	79
1900,	104
1901,	105
1902,	93
1903,	129
1904,	125
Total,	1,218

APPROPRIATIONS.

The appropriations for the year 1904, as recommended by the Board in the annual estimates made under the provisions of chapter 6, section 26, of the Revised Laws, were as follows: —

For the general expenses of the Board,	$23,000
For the inspection of food and drugs,	12,500
For the production and distribution of antitoxin and vaccine,	8,000
For the purity of inland waters,	34,000
For the examination of sewer outlets and Neponset River,	7,500
For printing the annual report,	4,000
Total,	$89,000

EXPENDITURES.

The expenditures in 1904 under the different appropriations were as follows: —

Appropriation for general expenses of Board,		$23,000 00

General Expenditures, Sept. 30, 1903, to Sept. 30, 1904.

Salaries,	$10,290 01	
Travelling expenses,	662 13	
Stationery,	376 75	
Printing,	2,119 14	
Books, subscriptions and binding,	393 60	
Advertising,	11 65	
Express charges,	282 29	
Extra services,	227 94	
Messenger,	16 20	
Postage and postal orders,	189 64	
Telephone and telegraph messages,	92 52	
Typewriter supplies,	3 75	
Special investigations,	56 55	
Sundry office supplies and incidental expenses,	664 59	
Laboratory supplies,	1,108 91	
Labor,	14 25	
		$16,509 92

Expenditures at Pathological Laboratory at Forest Hills for Three Months (Sept. 30, 1903, to Dec. 31, 1903).

Salaries,	$943 39	
Purchase of animals,	249 20	
Board of horses,	411 85	
Shoeing horses,	1 00	
Food for animals,	44 64	
Amounts carried forward,	$1,650 08	$16,509 92

Amounts brought forward,	$1,650 08	$16,509 92
Apparatus, chemicals and laboratory furnishings and supplies,	2,321 18	
Rental of telephone,	42 00	
Extra services,	10 00	
Travelling expenses,	4 30	
Express charges,	18 07	
Postage,	62	
Printing,	9 51	
Labor,	17 64	
		4,073 40
Total,		$20,583 32

Expenditures for the Production and Distribution of Antitoxin and Vaccine for the Nine Months, Jan. 1, 1904, to Sept. 30, 1904.

Appropriation for the calendar year 1904,	$8,000 00
Salaries,	$2,488 34
Purchase of animals,	179 90
Board of horses,	1,223 16
Food for animals,	100 63
Apparatus, chemicals and laboratory supplies,	1,354 24
Ice,	23 71
Stationery,	16 78
Rental of telephone and messages,	80 25
Services of veterinary surgeon,	12 00
Express charges,	129 48
Labor,	152 92
Extra services,	46 00
Printing,	60 87
Total,	$5,868 28

Under the Provisions of the Food and Drug Acts during the Year ended Sept. 30, 1904.

Appropriation,	$12,500 00
Salaries of analysts,	$5,000 00
Salaries of inspectors,	4,280 00
Travelling expenses and purchase of samples,	1,935 13
Apparatus and chemicals,	452 68
Printing,	39 02
Services (cleaning laboratory),	106 00
Express and postage,	10 33
Sundry laboratory supplies,	98 25
Books and maps,	97 30
Extra services (stenographer),	29 15
Typewriting supplies,	21 25
Total,	$12,069 11

Appropriation.

For carrying out the provisions of the act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage,	$34,000 00

Salaries, including wages of laborers at Lawrence Experiment Station,	$25,681 55
Apparatus and materials,	3,110 06
Rent of Lawrence Experiment Station,	150 00
Use of tools and office, Lawrence Experiment Station,	278 10
Travelling expenses,	1,931 37
Express charges,	982 84
Books, book binding, stationery and drawing materials,	496 83
Maps and blue prints,	194 43
Telephone and telegraph messages and postage,	60 22
Typewriter and typewriting supplies,	235 58
Printing,	340 06
Miscellaneous,	526 42
Total,	$33,987 46

The foregoing statement of expenses under the act to protect the purity of inland waters refers to the calendar year 1904.

Appropriation.

For the examination of sewer outlets, under the provisions of section 4 of chapter 75 of the Revised Laws,	$7,500 00

Salaries,	$4,474 60
Apparatus and materials,	1,329 00
Travelling expenses,	1,256 20
Stationery,	1 38
Maps,	11 90
Telephone messages,	3 20
Services, reading gauges and collecting samples,	414 31
Express charges,	1 95
Total,	$7,492 54

HENRY P. WALCOTT.
JAMES W. HULL.
CHARLES H. PORTER.
JULIAN A. MEAD.
HIRAM F. MILLS.
JOHN W. BARTOL.
GERARD C. TOBEY.

WATER SUPPLY AND SEWERAGE.

ADVICE TO CITIES AND TOWNS.

ADVICE TO CITIES AND TOWNS.

Under the provisions of the Revised Laws (chapter 75, section 117), the State Board of Health is required to

> consult with and advise the authorities of cities and towns and persons having, or about to have, systems of water supply, drainage or sewerage as to the most appropriate source of water supply, and the best method of assuring its purity or as to the best method of disposing of their drainage or sewage with reference to the existing and future needs of other cities, towns or persons which may be affected thereby. It shall also consult with and advise persons engaged or intending to engage in any manufacturing or other business whose drainage or sewage may tend to pollute any inland water as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of drainage or sewage. No person shall be required to bear the expense of such consultation, advice or experiments. Cities, towns and persons shall submit to said board for its advice their proposed system of water supply or of the disposal of drainage or sewage, and all petitions to the general court for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of said board thereon.

During the year 1904 the Board has given its advice to the following cities, towns and persons who have applied for such advice under the provisions of this act or under special acts relating to water supply and sewerage.

Official communications were made during the year under the provisions of acts relating to water supply and to sources of ice supply, as follows: —

Water Supply.

Ashfield.
Attleborough.
Attleborough (town farm) (two).
Attleborough (Watson-Newell Company).
Barnstable and Yarmouth.
Barre (Stetson Home).
Boston (spring at Jamaica Park).
Colrain.
Dalton.
Dartmouth (Bay View).
Easthampton.
Easton.
Gloucester (Y. M. C. A.).
Gloucester (Russia Cement Company).
Great Barrington (three).
Greenfield (two).
Hadley.
Hardwick (Gilbertville).
Harvard.
Haverhill.
Holland.

Holyoke.
Holyoke (Holyoke Valve and Hydrant Company).
Holyoke (Whitmore Manufacturing Company).
Hull.
Ipswich.
Lawrence (three).
Lawrence (well at City Hall).
Lawrence (Briggs & Allyn Manufacturing Company).
Lenox.
Lenox (New York, New Haven and Hartford Railroad Company).
Longmeadow.
Maynard (two).
Merrimac.
Millbury (E. G. Howe).
Milton (Houghton school).
Milton (Leopold Morse Home).
Northampton.
North Attleborough (two).
Northborough (almshouse).
Peabody.
Peabody (Frank T. Moore).
Plymouth (two).
Randolph and Holbrook.
Shelburne.
Shrewsbury.
Somerville (M. W. Carr & Co.).
Springfield (four).
Springfield (springs).
Stockbridge.
Uxbridge (three).
Wakefield.
Waltham.
Waltham (Alden Clark).
Wellesley (Wellesley College) (two).
Westford.
Weston (cemetery near source of water supply of Cambridge).
West Springfield.
Woburn (W. W. Cummings).
Worcester.
Wrentham.

ICE SUPPLY.

Chicopee.
Everett.
Falmouth.
Hardwick (Wheelwright).
Holyoke.
Littleton.
Milton.
Nantucket.
Palmer (Three Rivers).
Quincy.
Westport.

Official communications were made during the year under general and special acts relating to sewerage and sewage disposal, as follows: —

Brockton.
Fairhaven.
Falmouth.
Grafton (Colony for Insane).
Great Barrington.
Haverhill (two).
Holyoke.
Hubbardston.
Lenox (two).
Leominster.
Manchester.
Marblehead.
Northampton (two).
Norwood.
Norwood (Winslow Bros. & Smith Company) (two).
Pittsfield.
Rockland.
Rutland (Industrial Camp for Prisoners).
Salem (two).
Southborough (Deerfoot Farm Company).
South Hadley.
Wakefield.
West Springfield.

Replies were also made in answer to applications for advice relative to the pollution of ponds, streams and other bodies of water, as follows: —

Canton (Neponset Woolen Mills).
Leicester.
New Bedford.
Plymouth.
Quincy.
Swampscott.
Wellesley.
Winchester.
Woburn.
Worcester.
Worcester (Worcester Insane Hospital).

Water Supply.

The following is the substance of the action of the Board during the past year in reply to applications for advice relating to water supply: —

Ashfield.

April 7, 1904.

To the Board of Directors of the Ashfield Water Company.

Gentlemen: — The State Board of Health received from you on March 29, 1904, the following application for the advice and approval of this Board of the taking of Bear Swamp Brook, so called, and its tributaries as a source of public water supply for the town of Ashfield: —

> The Ashfield Water Company hereby makes application to the State Board of Health for its approval of Bear Swamp Brook in the town of Ashfield as a source of water supply for the inhabitants of said town.
>
> The Ashfield Water Company proposes to take the waters of Bear Swamp Brook, as authorized by chapter 77, Acts of 1904; to construct a reservoir on said brook of about 40,000 gallons' capacity, at an elevation of 335 feet above the village; to conduct the water through about 2,000 feet of 4-inch pipe to a service reservoir of 200,000 gallons' capacity, at an elevation of about 215 feet. From the service reservoir the water is to be conducted through 7,000 feet of 8-inch pipe to the village street, where it is to be distributed through 6-inch and 4-inch mains.

The Board has considered the results of recent examinations of the proposed source of supply and of analyses of the water, and has examined the plan submitted by you.

The point at which it is proposed to take water from the brook, as indicated in your plan, is just above the highway crossing, about one-fifth of a mile above the point where the brook crosses the main road leading from Ashfield to Hawley. Examinations made by the Board show that at the present time the drainage area of the brook above this point is free from dwelling houses or other possible sources of pollution, and that the water is of good quality for all the purposes of a public water supply.

The Board has no definite information showing the flow of Bear Swamp Brook in very dry weather, but is informed that the flow is well maintained; and it is probable that a sufficient supply of water will be secured from the reservoir which it is proposed to construct, taken in connection with the service reservoir referred to in your application, which it is understood will be supplied wholly from the Bear Swamp Brook, and not from another water-shed. If there should be a shortage of water at any time, it will be practicable to build a storage reservoir upon Bear Swamp Brook just above the intake reservoir now proposed there, and in this way secure an adequate supply.

The Board hereby approves the taking of Bear Swamp Brook at the point indicated above as a source of water supply for the town of Ashfield, under the provisions of chapter 77 of the Acts of the year 1904.

ATTLEBOROUGH.

OCT. 6, 1904.

To the Board of Water Commissioners of the Town of Attleborough, MR. GEORGE H. SNELL, *Superintendent.*

GENTLEMEN: — The State Board of Health received from you on August 17 the following application for advice relative to a proposed additional water supply for the town of Attleborough: —

> I hereby request your approval of certain improvements in the development of the present water supply. The present well does not permit of water being drawn from the ground at a rate such that the present pumping plant can be economically operated.
>
> It is therefore proposed to construct another well on the opposite side of Seven Mile River, and connect this new well with the present well by a masonry conduit laid at the elevation of bottom of well, this conduit to be of dry masonry, so as to serve as additional means of interception.
>
> Test wells have been sunk, and good material has been found.
>
> We submit with this application a blue print showing the proposed new work, also the location of the test wells.

The application was accompanied by a blue print showing the location of the proposed new well, and of test wells sunk in the neighborhood of the present and proposed wells to determine the character of the soil.

The plans provide for supplementing the present supply, which is drawn from a well 30 feet in diameter and 25 feet deep, located about 150 feet south-east of the Seven Mile River, a short distance above its entrance to Orr's Pond, by constructing a new well on the opposite side of the river, about 50 feet from the stream and 210 feet from the present well. The proposed new well is to be 40 feet in diameter, and to be sunk about 1 foot lower than the bottom of the present well.

The Board has considered the proposed plans, and has caused the locality to be examined by one of its engineers and samples of the water of the test wells to be analyzed.

The quality of the water of the present source of supply is excellent, but experience has shown that the yield of the well is hardly sufficient for the supply of the town under present conditions, and in a very dry season the quantity obtainable from this source would probably be inadequate. Analyses of samples of water from the test wells located in the neighborhood of the proposed new well show that the water does not differ materially in quality from that of the present source of supply, and the indications are that water of good quality would be obtained from the proposed well.

The test wells were sunk in porous soil, and water could be pumped from them very freely. Observations upon the height of water in these wells indicate that the ground water in this locality is already influenced by pumping from the present well; but by constructing the proposed well a much larger portion of the water stored in the ground in this region would be made available, and the area from which the water would filter toward the sources of supply be enlarged, so that a considerable increase in the yield of your sources of supply would be secured by the construction of the proposed works. It is very important to secure an additional supply without delay; and under the circumstances, in the opinion of the Board, the proposed well and conduit are a desirable addition to your sources of supply.

It is evident that much water from the Seven Mile River enters the ground in the region through which the proposed conduit will pass; and it is important, in laying this conduit, to exclude ground water from beneath the river bottom, or at any place where imperfectly purified water is liable to enter this channel.

ATTLEBOROUGH (TOWN FARM).

JUNE 2, 1904.

To the Board of Overseers of the Poor of the Town of Attleborough.

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to the quality of the water of a well recently put in at the town farm, and has caused the well and its surroundings to be examined by one of its engineers and a sample of the water to be analyzed.

The results of the analysis show that the water is grossly polluted, apparently by drainage and foul matter from an adjacent barn cellar, and is unfit for drinking. The Board would advise that this well be closed, and the possible use of its water for drinking or cooking be prevented.

DEC. 1, 1904.

To the Board of Overseers of the Poor of Attleborough, MR. BENJ. W. KING, *Chairman.*

GENTLEMEN: — In response to your request, the State Board of Health has again caused the well at the Attleborough town farm to be examined and a sample of the water to be analyzed. The results of the analysis show some improvement as compared with the first examination of the water of this well, but the water is still very badly polluted, and in the opinion of the Board is unfit for drinking.

ATTLEBOROUGH (WATSON-NEWELL COMPANY).

AUG. 4, 1904.

To the Watson-Newell Company, Attleborough, Mass.

GENTLEMEN: — The State Board of Health has caused an examination to be made of the water of driven wells located near your factory, which it appears have been put in with a view to furnishing a supply of water for manufacturing purposes and also for drinking in the factory, and has caused a sample of water from one of the wells to be analyzed. This well, which the Board is informed is 38 feet deep, is located about 300 feet from the factory in low land near the Ten Mile River.

The results of the analysis show that the water contains an excessive quantity of iron, which would make it objectionable for drinking and some other uses. The presence of this iron is probably caused by the imperfect filtration of water passing through the ground from the Ten Mile River, a stream which receives much pollution from villages above this point, and under the circumstances the Board does not advise the use of this water for drinking.

BARNSTABLE AND YARMOUTH.

JUNE 2, 1904.

To the Barnstable Water Company, MR. EBEN A. THACHER, *Temporary President,* 159 *Devonshire Street, Boston.*

GENTLEMEN: — The State Board of Health received from you on May 10, 1904, an application for the approval of a proposed source of water supply for the towns of Barnstable and Yarmouth, in which your proposed scheme is described as follows: —

> By the proposed system the supply of water will be obtained from driven wells located near the southerly end of Wequaquet Lake.
>
> The location of the wells, the details of their construction, and the land which it is proposed to purchase, are shown on the accompanying plans: 1. Plan showing location of proposed driven well system, Barnstable water works, dated May 9, 1904, Peirce & Barnes Company, engineers; 2. Barnstable water works, plan of driven well system, December, 1903, Alfred O. Doane, consulting engineer, and Peirce & Barnes Company, engineers.
>
> The system herein proposed is intended to be in accordance with the general recommendation of your Honorable Board, made last year in reply to an application for advice and approval of a plan to take water from Wequaquet Lake.
>
> It is believed that the system now proposed will not interfere in any way with the use of Wequaquet Lake and its shores for boating, fishing, hunting and other purposes for which the lake and its shores are now used.
>
> In advising the Barnstable Water Company upon the proposed system of water supply, your Honorable Board is requested to inform the company whether said system will in any way interfere with the uses to which the lake and its shores are now put. It is of considerable importance to the company to be informed on this point, as the company desires to take its supply from such places and in such a manner that there will be no interference with the present uses of the lake and its shores.

The application is accompanied by plans showing the location of the proposed tubular wells, as described in the foregoing statement.

In response to this application, the Board has caused the locality to be examined by one of its engineers and samples of water from two of the test wells to be analyzed.

The results of the analyses show that the water of these wells is soft, and otherwise of good quality for the purposes of a public water supply.

The results of tests made by pumping water from test wells in this locality show that water can be obtained freely from the ground by means of suitable collecting works, and, taken in connection with observations upon the height of the ground water, indicate that a sufficient quantity of water for the supply of the towns of Barnstable and Yarmouth can be obtained from the ground in this region; and the Board approves the use of ground water from the locality for the supply of the towns of Barnstable and Yarmouth.

In the opinion of the Board, the use of water from the ground in the locality indicated, provided that all collecting works are located 100 feet or more from the shores of the pond, and an adequate area is secured about the wells to prevent danger of pollution of the ground water in this neighborhood, need not interfere with boating, fishing or hunting upon Wequaquet Lake, or other proper and legitimate use of that lake or its shores.

BARRE (STETSON HOME).

SEPT. 1, 1904.

To MR. J. N. BARSS, *Superintendent Stetson Home, Barre, Mass.*

DEAR SIR: — In response to your request of August 4 for an examination of the water supply used at the Stetson Home, and advice as to its quality, the Board has caused the sources of supply to be examined by one of its engineers and has caused samples of the water to be analyzed.

It appears that the water supply is at present drawn from three wells: one a dug well, 30 feet deep, located about 50 feet south-east of the road to Barre; the second a 3-inch tubular well, 150 feet deep, located 20 feet south-east of the first well; and the third a well 25 feet deep, dug in the cellar of a dwelling house, the latter well being within about 20 feet of a privy vault. Water from the first two wells is pumped to a tank, whence it flows to a tank in the school building and is supplied for use there, the water of the third well being used only for the supply of the dwelling house.

The results of an analysis of the water of the well in the dwelling house shows that it has been considerably polluted; and, while at the time this sample was collected the water was being very thoroughly purified before entering the well, and was probably at that time safe for drinking, its quality is liable at any time to deteriorate, and it is advisable, in the opinion of the Board, to discontinue the use of this source.

Analyses of the water of the other two wells from which the supply used in the school is drawn show some evidence of previous pollution; but at the present time the possible sources of pollution are remote, and the Board is of the opinion that the water of these sources might safely be used for drinking. The water of the deep tubular well, however, contains such an excessive quantity of iron that it is objectionable for drinking and many other purposes. It would be practicable to remove the excessive quantity of iron by means of a properly constructed filter; but the expense of constructing and maintaining such a filter would probably be greater than the cost of obtaining a new supply by sinking a well in a locality where the water is not affected by the presence of an excessive quantity of iron.

Boston (Jamaica Park).

July 7, 1904.

To the Board of Commissioners of the Department of Parks, Jamaica Plain, Mr. George F. Clarke, *Secretary.*

Gentlemen: — In response to your request of June 3 for an examination of the water supplied from the city mains at Jamaica Park, and also of the water of a spring in the park near the corner of Chestnut and Perkins streets, the Board has caused the locality to be examined and samples of the waters indicated to be analyzed.

The water from the city mains, you state, is so full of sediment at times as to be undrinkable, usually being worse in the morning than at other times. This is doubtless due to the fact that the faucet from which the water is drawn is located at the end of a long section of pipe from which there are no other takers. It is probable that, by providing a proper means of flushing this pipe, and by flushing it in the morning before water is drawn for drinking, the water would be of satisfactory quality.

The water of the spring near the corner of Chestnut and Perkins streets is of good quality for drinking. The spring is exposed to possible pollution by fertilizers or other matters deposited upon the slope above the spring, which might be carried into the spring at times of rain. If provision should be made to prevent matters deposited here from being washed into the spring, and if the spring should be covered so that it would not be polluted by persons dipping up water, this spring would be a safe source from which to take water for drinking.

Colrain.

July 21, 1904.

To Messrs. W. S. Allard, Charles A. Macey and Charles J. Russell, *Commissioners of the Colrain Fire District No. 1.*

Gentlemen: — The State Board of Health has considered your request of June 27 for the advice and approval by this Board of the taking for domestic purposes, under the provisions of chapter 318 of the Acts of the year 1902, of the waters of Mountain Brook, so called, in the town of Colrain, and has caused the proposed source of supply to be examined by its engineer and a sample of the water to be analyzed.

The water, as indicated by the analysis of a sample collected recently at the reservoir already constructed by the district, though somewhat hard, is in other respects of good quality for the purposes of a public water supply; and an examination of the water-shed shows that this area is practically uninhabited above the point where your reservoir is located, the only dwelling house in the neighborhood being so close to the limit of the water-shed that it is unlikely that polluting matters from this place can affect your source of supply.

The water of the reservoir is unfavorably affected at times by street wash from a road which passes near the head of the reservoir. The street wash could be conveyed in the gutter on the opposite side of the street from the reservoir to a point of discharge into the brook below the reservoir without special difficulty, and this change should be made before the water is used for domestic purposes.

While the quantity of water which this source will yield in dry weather is evidently small, it is likely to be sufficient for the requirements of the village; and the Board hereby approves the taking of Mountain Brook at the reservoir now located on that stream as a source of water supply for domestic purposes for the village of Colrain.

DALTON.

Nov. 3, 1904.

To the Board of Water Commissioners of the Dalton Fire District.

GENTLEMEN: — In accordance with your request, the Board has caused an examination to be made of Anthony and Beall's brooks, with a view to their use as sources of water supply for Dalton, and has caused samples of their waters to be analyzed.

The water-shed of Anthony Brook, which is contiguous to that of your present source — Egypt Brook — on the west, is uninhabited, and the waters of the two branches, while somewhat colored with vegetable matter, are of good quality for drinking.

The water-shed of Beall's Brook contains one dwelling house, unoccupied, however, at present, and two buildings which are said to be occupied during the winter. The analyses of the water show that it is naturally of good quality for water-supply purposes, and if suitable provision is made for preventing pollution of the stream from buildings on the water-shed, this stream may safely be used as a source of water supply for Dalton.

Regarding the quantity of water which these sources are likely to yield in the drier part of the year, it is not practicable to make a definite estimate, but with the aid of the storage in your reservoirs the use of these streams is likely to add considerably to the quantity of water available for the supply of the district; and the cost of works for obtaining water from these sources is not likely to be very large in the case of Anthony Brook, while in the case of Beall's Brook a pipe line of sufficient size can be laid so that it may be extended, when necessary, to May Brook farther east.

In the opinion of the Board, Anthony and Beall's brooks are appropriate sources of additional water supply for Dalton.

DARTMOUTH (BAY VIEW).

SEPT. 1, 1904.

To MR. CHARLES W. HOWLAND, *Chairman Board of Health, Dartmouth, Mass.*

DEAR SIR: — In response to your request for an examination of the water of a well used as a source of water supply for the summer settlement of Bay View, and advice as to its quality, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

This source was examined by the Board in 1899, and at that time the owner was advised that the water showed evidence of having been at some time polluted but subsequently well purified in its passage through the ground before entering the well, and that the water, under the conditions existing at that time, was suitable for drinking and other domestic uses. Since the time of the previous examination a tubular well has been driven in the bottom of the large well to a depth of about 100 feet.

Upon comparing the results of the recent analysis with the results of the previous test, it is found that the water has deteriorated slightly in some respects, but the indications are that it was safe for drinking at the time the recent examination was made.

There are cesspools and other places where sewage is deposited in the ground not far from the well, and the danger in the use of such a source is that some change in the conditions affecting the pollution of the water may at any time cause it to deteriorate in quality and become unsafe for drinking; and the Board would advise that while this source is continued in use its condition be examined carefully from time to time, and its use discontinued if deterioration occurs. It is desirable that a water supply from some unpolluted source be obtained for this village, and the further use of the present source discontinued.

EASTHAMPTON.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on July 7, 1904, for preventing the pollution and securing the sanitary protection of the waters of Bassett Brook and its tributaries, used by the town of Easthampton as a source of water supply.

EASTON.

OCT. 6, 1904.

To Mr. WILLIAM H. AMES, *Water Commissioner, North Easton Village District, North Easton, Mass.*

DEAR SIR: — In accordance with your application of August 4 for an examination of the water of two deep tubular wells located on either side of your present well, the Board has caused the locality to be examined and samples of the water of the wells to be analyzed.

The results of the analyses indicate that the water of well No. 1 is of good quality for the purposes of a public water supply, the quality differing but little from that of your present well. The water of well No. 2 is not satisfactory.

Well No. 1 is distant about 75 feet from the present well, and, while it was sunk to a much greater depth than the present well, it was bored largely in rock, and it is unlikely that the yield of your sources of supply will be materially increased by the use of this well.

The consumption of water in the North Easton village district is increasing rapidly, and it is unlikely that the yield of the sources of supply, including the new well, would be sufficient for the requirements of the village in the drier portion of a dry season.

The reservoir located near the well is supplied with water from the Queset River, a stream which receives considerable pollution; and the water of this reservoir should not be used for the supply of the town unless filtered in a proper manner before being introduced into the water-supply system.

It appears that there is a system of pipes laid beneath the bottom of this reservoir, with a view to collecting ground water. The Board is informed that water from this source has not been used, and no knowledge is available as to its quality. Judging from experience with similar systems for collecting water in other places, the quality of the water obtainable from these pipes would be likely to be objectionable for many domestic uses, and imperfectly filtered water from the reservoir might find its way into them.

In the opinion of the Board, it is advisable for the district to cause an investigation to be made, with a view to obtaining an additional source of water supply which may be available for use when necessary. There appear to be opportunities for securing an additional supply of water from the ground at several places at no great distance from your present well, and it may also be practicable to filter water from the Queset River through the gravelly land bordering the stream, and secure water of good quality and in sufficient quantity for the additional requirements of the village.

Should you decide to make further investigations, the Board will, upon application, give you such assistance as it can in the matter by making the necessary analyses of samples of water, and will give you further advice when the results of further investigations are available.

Gloucester (Y. M. C. A.).

June 2, 1904.

To Mr. Reuben Brooks, *Chairman, Building Committee of Y. M. C. A., Gloucester, Mass.*

Dear Sir: — In response to your request of May 9 for advice as to the quality of the water of a well which it is proposed to use as a source of water supply for the Y. M. C. A. building in Gloucester, the Board has caused the well and its surroundings to be examined and a sample of the water sent in by you to be analyzed.

The results of the analysis show that the water of this well is grossly polluted by sewage, and is also probably affected by sea water, and the Board would advise that the possibility of its use for drinking or cooking be prevented.

Gloucester (Russia Cement Company).

Sept. 1, 1904.

To Mr. Reuben Brooks, *President Russia Cement Company, Gloucester, Mass.*

Dear Sir: — In response to your request of July 30, the Board has caused certain wells at your factory, which you propose to use as a source of drinking water supply for the operatives, to be examined and a sample of the water to be analyzed.

The wells indicated are located in the bottom of a pond near the factory, and the Board is informed that they have been driven to a depth of about 25 feet beneath the bottom of the pond.

The pond is a small artificial reservoir, the water of which is exposed to pollution from several buildings on its water-shed. The water of the wells gives evidence of considerable pollution, and the water of wells located in the bottom of a pond, as these are, is likely to deteriorate after a considerable quantity of water has been drawn. The water does not appear to be unsafe for drinking at present, but, since its quality is liable to deteriorate, the Board would advise that it be examined from time to time, and its use discontinued if deterioration occurs.

Great Barrington.

March 3, 1904.

To the Water Committee, Great Barrington, Mass., Mr. George D. Goodrich, *Chairman.*

Gentlemen: — The State Board of Health has considered your application for advice as to the taking of Seekonk or Alford Brook as a source of water supply for Great Barrington, and has caused the source to be examined by one of its engineers.

It appears from oral statements by members of your committee that two plans are under consideration, though no definite information concerning either of them has been submitted to the Board.

One plan provides for taking water from the brook at a point near its mouth, using the water of Green River to furnish power for pumping, and all of the water supplied from this source would have to be pumped by this plan. The examinations made by the Board show that the water of the brook at this point is not only objectionable on account of hardness, but that it will probably be impracticable to adequately protect it from pollution; and, in the opinion of the Board, Seekonk Brook at this point is neither a desirable nor a safe source of water supply.

By the second plan the Board is informed that a small dam would be constructed across the brook, about five miles above its mouth and about a mile and a half above the village of Alford. By this plan water could apparently be supplied to the town by gravity under a somewhat greater pressure than is furnished by the present low-service system, but the source would not be high enough to supply the high-service system.

The water of the brook at this point also is objectionably hard, and, as there is a considerable population in buildings located close to the brook and its tributaries above this point, and much of the land is highly cultivated, the protection of the source from pollution would be difficult and expensive. In the opinion of the Board, this brook is not a desirable source of water supply for the fire district.

Other sources offering greater advantages both in respect to the quality of the water and the economy of constructing works appear to be available, but adequate investigation of these sources has not yet been made to determine the quantity or quality of water that they can be depended upon to yield by any practicable plan of development.

Nov. 3, 1904.

To the Committee on Water Supply of the Great Barrington Fire District, Mr. A. C. Collins, *Chairman.*

Gentlemen: — The State Board of Health received from you on Oct. 4, 1904, an application, under the provisions of section 117, chapter 75 of the Revised Laws, requesting the advice of the Board as to a proposed water supply for Great Barrington, in which you state: —

> The advice of the Board is desired on the adoption of the source of supply described and recommended by Mr. Percy M. Blake, viz., the Goodale Brook in the town of Mt. Washington, in his report, a copy of which has been forwarded to you. Or, if such source does not receive the approval of your Board, it is desired that you recommend such other source, of those described by Mr. Blake, as may be best adapted to the needs of the district.

The application is accompanied by a report of your engineer, Mr. Percy M. Blake, in which various possible sources of water supply are considered, with the final recommendation that water be introduced from Goodale Brook and a portion of the water-shed of Wright Brook, supplemented when necessary with water from Fenton Brook.

The plan provides for the construction of two storage reservoirs on Goodale Brook, each to hold about 24,000,000 gallons; and a canal is indicated, running from the southerly end of the water-shed of Goodale Brook across a portion of the water-shed of Wright Brook, by which it is proposed to intercept some of the flow of the latter water-shed and divert it into Goodale Brook. At Fenton Brook it is proposed to construct a reservoir holding about 1,500,000 gallons of water at about the same elevation as the lower reservoir on Goodale Brook, and to construct a branch pipe line from this reservoir to the main pipe from Goodale Brook to the village.

Several other possible sources of supply have been considered by your engineer, and estimates of the cost of works for obtaining water from these sources are submitted.

The Board has caused the various sources available for the water supply of Great Barrington to be examined by its engineer, and has considered the information that has been collected and submitted concerning them and the results of the analyses of the various waters. Of the various sources considered, Goodale Brook, Prospect Lake and Harmon Brook have decided advantages both in the matter of economy and in other respects over any of the others that have been mentioned as possible sources of water supply for Great Barrington. The water of Goodale Brook as it flows in the stream is softer than that of either Prospect Lake or Harmon Brook, and is nearly free from color. The water of Prospect Lake is also nearly colorless, while the water of Harmon Brook is somewhat colored. It is probable that the water of Prospect Lake is affected at times by growths of organisms which impart to the water a disagreeable taste and odor, and the waters of Goodale Brook or Harmon Brook would probably be affected in a similar way by storage in the reservoirs which it would be necessary to construct in order to obtain a sufficient supply from these brooks. The principal advantage in quality that either of the sources would possess over the others after development as proposed would be that the water of Goodale Brook would probably be somewhat softer than that of Prospect Lake or Harmon Brook.

The water-sheds of all three sources contain dwelling houses and farm buildings, and it would be necessary in each case to make provision for the prevention of the pollution of the source from such places.

Harmon Brook, developed as proposed by your engineer, would yield an ample quantity of water for the present and future requirements of Great Barrington, so far as they can now be foreseen, and the source is capable of further development. Prospect Lake would probably yield at present enough water for the requirements of the district in the driest of seasons; and the investigations have shown that it is practicable to increase the yield of the lake by raising its level and diverting into it the waters of adjacent water-sheds, so that it will be capable of furnishing an ample supply for the present and future requirements of the district. By constructing both the reservoirs suggested on Goodale Brook, holding together 48,000,000 gallons, a somewhat greater quantity of water than the estimated amount now used by the district could be obtained from this source; and by using in connection therewith the portion of the Wright Brook and Fenton Brook water-sheds that can be made available, enough water can be obtained from this source to supply a population much larger than that now living in the district, unless the use of water should be excessive. There appears to be no practicable plan of developing this source further than is indicated in the plans submitted, and it is doubtful whether it can be depended upon in a very dry year to yield more than about 750,000 gallons per day.

The estimates of cost submitted indicate very clearly that, if all items of cost and damage be included, the cost to the district of taking a supply of water from Prospect Lake would be considerably less than the cost of an adequate water supply from Goodale Brook or from Harmon Brook.

Considering all the circumstances, the Board is of the opinion that the most appropriate source of water supply for the district is Prospect Lake and the water-sheds contiguous thereto. Goodale Brook, however, developed and supplemented as proposed, would furnish a sufficient quantity of good water to supply the needs of the district for several years, and possibly for many years if the growth should be slow and the use of water moderate. Aside from the greater cost of the works, there is no objection to the taking of a supply of water from Goodale Brook, supplemented with water from Wright and Fenton brooks.

JAN. 5, 1905.

To the Committee on Water Supply of the Great Barrington Fire District, MR. A. C. COLLINS, *Chairman*.

GENTLEMEN: — The State Board of Health received from you on Nov. 22, 1904, a communication requesting further advice relative to the proposed sources of water supply for the Great Barrington Fire District, as follows: —

> Your communication of November 3, relative to a proposed water supply for Great Barrington, was duly received and contents noted.
>
> We appreciate your suggestions in regard to Prospect Lake as a more economical supply and possibly a larger supply than Goodale Brook, which is recommended by Mr. Blake in his report. Our committee, however, have much hesitation about recommending Prospect Lake to the fire district, on account of the quality of the water. Of course we appreciate the fact that the quality would be improved by raising the dam and increasing the depth of water; but so much is said about the strong odors from the lake during the hot weather, that we very much doubt if this objection can be entirely overcome. We dislike to take any chances on the quality of the water that we are to get, especially during the summer months, when many people from the cities are likely to be here, and when we should be especially criticised for any disagreeable odors or color in the water.
>
> Would there, in your opinion, be any difficulty in removing the color to the water of Harmon Brook, as suggested in Mr. Blake's report? This source of

supply would be undoubtedly an adequate one, but is subject to some criticism on account of the color.

The city of Springfield has had so much trouble with the quality of its water supply that we do not want to take any chances in that respect. While there is not the abundance of water in Goodale Brook that we could wish, yet its quality is so excellent that we feel very friendly to Mr. Blake's report in favor of that supply, as he seems to regard it as adequate.

None of our committee has any special prejudice in favor of either supply. We simply want to solve the problem, if possible, for the best interests of the fire district, and to correctly settle the long-vexed problem.

Dr. Lane, who is a member of our board of health, feels very strongly that the water of Prospect Lake would not be satisfactory during the summer months unless a large amount were expended in cleaning the lake. I enclose herewith a copy of a communication which I have just received from him on this subject.

If I understand your letter correctly, you are prepared to approve either Goodale Brook or Harmon Brook, in case the district should adopt either of these sources in preference to Prospect Lake. Is this correct?

The information available to the Board as to the character of the water of Prospect Lake is that which is furnished by the results of analyses of samples of this water collected in August, 1899, and in the months of July and October, 1904; and the results of examinations of the lake and its surroundings by its engineer, and the information furnished by the investigations of your engineer, Mr. Blake. The water collected from the lake in August, 1899, had a vegetable odor when examined by the severe tests of the laboratory, but the other samples were odorless. A very faint odor was developed in two samples upon heating the water. The quantity of organic matter present in the water, as indicated by the albuminoid ammonia in these samples, was no greater than is found in good pond or reservoir waters in the warmer portion of the year, and the water had but little color.

Nearly all surface waters, when stored in ponds or reservoirs, are affected at times by growths of organisms which impart to the water a disagreeable taste and odor, and it is not unlikely that the water of Prospect Lake would be affected at times in this way, as you have already been advised; but, so far as the analyses show, this water is not likely to be seriously affected by tastes or odors in the summer season.

Examinations of the lake and its surroundings show that the conditions are naturally favorable for the storage of water; and if the lake should be drawn down, the bottom cleaned and the organic matter removed from the areas which would be flowed by reason of raising its level, the danger that the water would be objectionable on account of disagreeable tastes and odors would be diminished. These improvements could apparently be made without serious difficulty.

If either Goodale Brook or Harmon Brook should be used as a source of water supply by the district, it would be necessary, in order to secure a sufficient supply, to construct reservoirs upon them and use the reservoir waters in the drier portion of the year. The waters of these reservoirs would be liable to be affected in a manner similar to that of Prospect Lake, and it is not practicable to tell beforehand whether they would be affected in a greater or less degree than the lake water.

If the water of Harmon Brook should be filtered in a proper manner, it is probable that the color would be somewhat reduced; but experience with the operation of water filters covering a period of more than ten years shows that the greatest reduction of color by filtration is unlikely to exceed about 30 per cent., and that in some years the reduction would not be much over half as great, and the color of the water of Harmon Brook after filtration would probably be somewhat greater than that of Prospect Lake.

The only practicable plan of insuring a water free from taste or odor from either of the sources will be to filter the water; and works constructed for supplying water to the district from either of the three sources could be so designed in the beginning as to allow for the subsequent introduction of filters, if, after experience, it should be found that the quality of the water was objectionable on account of taste or odor, and that filtration was desirable. The condition of Prospect Lake is not at all comparable with that of the water supply of Springfield, the water of the latter city being taken from a very large reservoir formed by flooding an area containing an extensive swamp, without removing stumps, muck and other organic matter.

The Board is prepared to approve either Goodale Brook or Harmon Brook, developed as proposed in the plan most recently submitted, in case the fire district should adopt either of these sources in preference to Prospect Lake.

GREENFIELD.

JULY 7, 1904.

To Messrs. C. J. DAY, E. A. NEWCOMB and CHARLES R. LOWELL, *Water Commissioners and Prudential Committee, Greenfield Fire District.*

GENTLEMEN: — The State Board of Health has considered your application of June 16 for advice as to the preparation of the bottom of the proposed new storage reservoir for the water supply of the Greenfield Fire District now under construction upon Glen Brook, a short distance above your present reservoir, and has caused the locality to be examined by its engineer.

It appears that the new reservoir will be formed by a dam about 40 feet in height, which will flood an area of about 7.1 acres to an average depth of about 17 feet. The storage capacity of the proposed new reservoir will be about 40,000,000 gallons, and the total storage capacity of this and the present reservoir, taken together, will be about 64,000,000 gallons.

The water of Glen Brook is clear and nearly colorless, and contains naturally but little organic matter. Experience with such waters has shown that they deteriorate when stored in reservoirs, and are affected at times by the presence of minute vegetable organisms in suspension in the water which often impart to it a disagreeable taste and odor. Trouble from this cause has been slight with the water of your present reservoir, probably, in part at least, on account of the fact that the capacity of the reservoir is small in proportion to the size of the water-shed, so that the water changes rapidly at all seasons of the year.

The water stored in the proposed new reservoir will change less rapidly, and there will be a greater opportunity for the development of organic growths which cause disagreeable tastes and odors in water than in the case of the present reservoir, since the water will be stored for a longer time.

Experience shows that such organic growths develop less extensively in reservoirs which have been carefully prepared for the storage of water by the removal of all of the soil and organic matter from the area flowed than in those which have received less thorough preparation ; and it is desirable to diminish the possibility of serious trouble from this cause by removing materials liable to promote organic growths.

The area to be flowed consists of the steep and rocky sides of a narrow glen, originally covered with a heavy growth of wood, which has been cut down and is being removed. The soil of this area consists chiefly of hardpan and rock, overlaid in places by a thin layer of loam or vegetable mold, composed in part of decayed leaves, sticks, etc. The Board would advise that all stumps and vegetable matter be removed from this area, including also such soil as may contain roots or grasses, so that the surface exposed to the water may be free from such organic matters.

In the work of constructing the dam and preparing this reservoir, which has already been begun, it will be necessary to introduce a considerable number of laborers into the water-shed above the reservoir from which your present supply is drawn ; and, in order to protect the purity of your present source of supply while this work is in progress, it will be necessary for you to provide means for the sanitary protection of your water supply, and to exercise such supervision of those employed on the work as will insure the protection of the water supply from pollution. The Board regards this matter of the greatest importance, since serious epidemics have resulted from the introduction of laborers into a water-shed used as a source of public water supply, under such circumstances as these.

It also appears, from an examination of the water-shed of Glen Brook above your present reservoir, that the water is exposed to considerable danger of pollution from several groups of farm buildings, some of which are near the streams feeding the reservoir. By the enforcement of suitable sanitary rules and regulations it will be possible to protect your sources of supply from pollution from most of these places. Some of these places are so situated with respect to the streams that it will be difficult to protect your sources of supply efficiently from pollution from these places; and, in order to secure adequate protection, it will be necessary for the town to secure control of some of the lands within this water-shed. It is especially important that a sufficient area should be controlled about your reservoirs to protect them from possible pollution. The Board will, if you so request, provide rules for the sanitary protection of your water supply, as authorized by chapter 75 of the Revised Laws of Massachusetts.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on Aug. 4, 1904, for preventing the pollution and securing the sanitary protection of the waters of Glen Brook Reservoir and its tributaries, used by Fire District No. 1 in the town of Greenfield as a source of water supply.

HADLEY.

Oct. 6, 1904.

To Messrs. F. H. Smith and E. S. Allen, *Water Supply Committee of the Town of Hadley.*

Gentlemen: — The State Board of Health, in accordance with your application of Aug. 23, 1904, for advice as to obtaining a water supply for the village of Hadley from the streams known as Sheep Pasture Brook, Middle or Stony Hill Brook, and Shingle Mill Brook, in Hadley, has caused these sources to be examined by one of its engineers and samples of their waters to be analyzed.

The results of the analyses show that the waters of these sources were at this time clear and nearly colorless and contained little organic matter, and were in other respects of good quality for the purposes of a public water supply. It is unlikely that the quality is very different at other seasons of the year. The water-sheds are at the present time uninhabited, and the waters can be protected from pollution in the future without difficulty.

Regarding the quantity of water which these sources can be depended upon to furnish, very little information is available, though weir measurements made during the past summer indicate that the flow is well maintained in ordinary years. It is very doubtful, however, whether the flow of the three sources taken together would be sufficient for the supply of the town unless provision should be made for storing water in a reservoir for use in the drier portion of the year. An examination of the water-sheds of the brooks shows that upon one of them there is a favorable site for a storage reservoir which would apparently hold from 3,000,000 to 4,000,000 gallons; and if further investigations shall show that it is practicable to construct a storage reservoir of the size indicated on either of the streams and to divert the waters of the other streams into the reservoir, it is probable, in the opinion of the Board, that an adequate supply of water for the village of Hadley could be obtained from the three streams indicated, and at less expense than in any other way. If this plan should be adopted, and an additional supply should become necessary, it could probably be obtained from other water-sheds in this neighborhood.

Hardwick (Gilbertville).

April 7, 1904.

To the Board of Health of Hardwick, Mr. Charles F. Angell, *Agent*.

Gentlemen: — In response to your communication received March 26, 1904, requesting an examination of the water supplied to the village of Gilbertville with reference to its action upon lead pipes, through which the water is supplied, the Board has caused the sources to be examined and samples of their waters to be analyzed.

It appears from this examination that the water supply of the village, which is drawn from springs on neighboring hillsides, is supplied exclusively through lead pipes, the length of lead pipe between the source of supply and the consumers being in some cases nearly half a mile.

The results of the analyses of samples of water collected in houses supplied from four different sources showed in all cases that the water dissolves lead from the pipes, the quantity dissolved in some cases being sufficient to cause lead poisoning. At other seasons of the year and with other conditions it is not unlikely that even greater quantities of lead are dissolved from the pipes than at the present time.

The Board would advise that the lead pipes used to supply water to Gilbertville be removed without delay, and pipes substituted which will not be attacked by the water, or, if attacked, will not injure the health of those who use the water for drinking or cooking. The danger of lead poisoning can be avoided by the use of pipes of tin, of lead properly lined with tin, or of iron lined with tin or with cement.

Harvard.

March 3, 1904.

To Dr. William N. Cowles, *Ayer, Mass.*

Dear Sir: — In response to your communication of January 18 for an examination of certain wells in the town of Harvard which have been suspected of causing lead poisoning, the Board has caused samples of water to be collected from four wells indicated by you, the results of which are enclosed herewith.

The results of the analyses show that the water of all of these wells dissolves lead from the pipes, and the quantity of lead present in the samples collected from the Chace and Mongovan houses would be very likely to cause lead poisoning.

The Board would advise that the lead pipes used to supply the water in these two houses be removed without delay, and pipes substituted which will not be attacked by the water, or, if attacked, will not endanger the health of those who use the water for drinking or cooking.

In the case of the other two houses it is possible that at other seasons of the year and under different conditions the quantity of lead taken up by the pipes would be larger than was shown by the recent analyses; and, to avoid danger of lead poisoning in these cases also, it would be advisable to remove the lead pipes and substitute other pipes which will not be acted upon by the water; but both of these wells are badly polluted, and it is desirable that the use of these sources be discontinued, and water introduced from some other source. Danger of lead poisoning can be avoided by the use of pipes made of tin, or of lead properly lined with tin, or of iron lined with tin or with cement.

HAVERHILL.

JAN. 5, 1905.

To the Board of Water Commissioners of the City of Haverhill.

GENTLEMEN: — In response to your request for information as to the cause of the offensive taste and odor of the water of Johnson's Pond, supplied to the Bradford district, the Board has caused examinations of the water, both of the pond and distributing system, to be made, and finds that the objectionable conditions are due to the organism *Uroglena*, which is present in the water of the pond in very large numbers. The Board is unable to advise you as to the cause of the presence of this organism in the water of the pond. It is not known whether the use for drinking of water containing this organism would be injurious to health, or not.

The city of Haverhill has other independent sources of water supply, which are not apparently at the present time affected by disagreeable tastes and odors; but no provision appears to have been made for supplying water from these sources on the Bradford side of the river. The Board would advise that one way of overcoming the difficulty is by connecting the works in the Bradford district with those on the Haverhill side of the river, so that it will be practicable to supply the Bradford district with water from one of the other sources at times when the water of Johnson's Pond is affected by disagreeable tastes and odors, as at present; and there might also be times when it would be desirable to use the water of Johnson's Pond in the portion of the city north of the river.

The Board would further advise that the objectionable tastes and odors could be removed from the water of Johnson's Pond by filtration; and this is the only safe and practicable way known to the Board of removing from this water the organisms and the objectionable taste and odor which they cause.

HOLLAND.

JULY 7, 1904.

To Mr. A. F. BLODGETT, *Secretary of Water Committee, Holland, Mass.*

DEAR SIR: — In response to your request for an examination of the water of a certain spring in Holland and advice as to the use of this source for a water supply for a schoolhouse, town hall and one or two other buildings in the village, the Board has caused the spring and its surroundings to be examined by one of its engineers and samples of the water to be analyzed.

The results of the analyses show that the water is soft and colorless, and evidently of good quality for the purposes of a public water supply, provided that it be protected from the entrance of surface water, by which it was affected somewhat at the time the samples were collected for analysis.

The Board is unable to advise you as to whether the quantity of water which this spring will furnish will be sufficient for the requirements of the buildings and dwelling houses which are in need of a water supply. At the time the examination was made the spring was full, but little or no water was flowing away from it. It seems likely that, by excavating a well or basin at the spring and laying a pipe from near the bottom of the excavation, a sufficient flow of water for the village could be obtained at all times.

The Board would advise that, before laying a pipe to take a supply from this source, you cause a test of its yield to be made by drawing water from the spring daily in approximately the quantity that will be required for the supply of the village, and observe whether by this test the water returns and maintains its level, or whether the spring is gradually becoming exhausted. If, by such a test, the yield of the spring is found sufficient, the Board is of the opinion that the source will be a suitable one for the requirements of the village.

HOLYOKE.

NOV. 3, 1904.

To the Board of Water Commissioners of the City of Holyoke.

GENTLEMEN: — In response to your request for advice as to prevention of the pollution of Manhan Brook, one of your sources of water supply, by a group of farm buildings situated between two tributaries of the brook, a short distance north of the road leading from Westhampton to Norwich Hill, the Board has caused an examination of the locality to be made by one of its engineers, and has considered the plan presented.

An examination of the surroundings shows that the stream is now being polluted by foul drainage from the buildings; and the situation of these buildings is such that it is impracticable, under the existing conditions, to prevent the pollution of the stream from this place. The plan submitted provides for diverting the flow of the west branch of the stream, into which the drainage now finds its way, into the east branch at a point some distance above the farm buildings, where the flow was evidently once diverted at some previous time. It is also proposed to put in a second channel immediately above the farm buildings, to divert any waters which may find their way into the bed of the west branch below the upper point of diversion.

It will probably be practicable, by carrying out this plan, to prevent any direct pollution of the brook from the farm buildings, and the cost of the necessary works will not be large. The situation of these buildings, however, is such that they will continue to menace the purity of the water at all times, and it is advisable, in the opinion of the Board, for the city to secure control of these buildings without delay, and prevent their further use. When this is done the Board would advise that rules and regulations be secured and enforced to protect the remaining part of this water-shed.

HOLYOKE (HOLYOKE VALVE AND HYDRANT COMPANY).

AUG. 4, 1904.

To Mr. JOHN J. SULLIVAN, *Vice-President and Manager, Holyoke Valve and Hydrant Company, Holyoke, Mass.*

DEAR SIR: — In accordance with your request of June 21 for an examination of the water of a tubular well at your factory, used for drinking by the employees and others, the State Board of Health has caused the well and its surroundings to be examined and several samples of the water to be analyzed.

The results of the analyses show that the water of this well has at some time been considerably polluted by sewage, but subsequently very well purified in its passage through the ground before entering the well. The quantity of organic matter present in the water is larger than is found in good ground waters, and, while this water is probably safe for drinking at the present time, changes in the height of the ground water or other circumstances may at any time render it unsafe, and the Board cannot recommend its continued use for drinking.

HOLYOKE (WHITMORE MANUFACTURING COMPANY).

AUG. 4, 1904.

To the Whitmore Manufacturing Company, Holyoke, Mass., MR. F. D. HEYWOOD, *Treasurer.*

GENTLEMEN: — In response to your request of July 11 for advice as to the quality of the water of a tubular well recently driven at your works in Holyoke, which it is proposed to use for drinking, the State Board of Health has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that this water, while it has been slightly polluted at some time before entering the well, and is somewhat hard, is in other respects of good quality and safe for drinking at the present time.

The well is located in a densely populated part of the city, however, and the quality of the water may change materially after a considerable quantity has been drawn from the well. It cannot be determined, until much more water has been drawn from the well, whether the water will continue to be safe for drinking; and, if used for that purpose, the water should be analyzed from time to time, and its use discontinued if the quality should seriously deteriorate.

HULL.

JAN. 5, 1905.

To the Board of Health of the Town of Hull.

GENTLEMEN: — The State Board of Health received on December 30 from Dr. W. H. Sturgis, physician to the board of health of the town of Hull, the following communication relative to the quality of the water supplied to that town: —

> It is the desire of the Hull board of health that I ask your aid in determining the purity of the water supplied to the town for drinking and other purposes.
>
> For about four weeks the water (which we understand is not the same previously supplied) has given off such an odor and has such a disagreeable taste that it is nearly impossible to drink it. There is also a large number of cases of diarrhœa, which may possibly come from the water.
>
> The complaints from the people are so constant that we consider it our duty to determine the purity of this water.

In response to this request the Board has caused the sources of the water supplied by the Hingham Water Company to the towns of Hingham and Hull to be examined by one of its engineers and samples of water from the sources of supply and from faucets in Hull to be analyzed.

It appears from this examination that up to within a short time the water supplied to the town of Hull was drawn from a well and a system of pipes for collecting ground water near Fulling Mill Pond; and the results of analyses of this water show that it is clear and colorless, contains but little organic matter, and is otherwise of good quality for the purposes of a public water supply. This water was supplied by pumping, but recently the pumping machinery was shut down for repairs, and the towns have been supplied with water by gravity from Accord Pond in Hingham. An examination of the water of this pond shows that it contains the organism *Uroglena* in large numbers, and it is to the presence of this organism in the water that the offensive taste and odor complained of in Hull at the present time are undoubtedly due. The water supplied to Hingham and Hull from Accord Pond has been objectionable for the same reason in previous years.

The Board is unable to advise you as to the cause of the presence of this organism in the water of Accord Pond, or as to any safe plan for preventing its appearance and the objectionable taste and odor which it produces.

If an adequate pumping plant should be provided, it is probable that enough water could be obtained from the well and other works near Fulling Mill Pond for the supply of both towns under ordinary circumstances; but if not, the water of Accord Pond could be filtered through filters constructed near Fulling Mill Pond, and a water free from taste and odor could in this way be supplied at all times.

The Board will make a further investigation, to determine if possible whether the use of the offensive water now supplied to Hull is the cause of sickness, as suggested in the above communication, and will inform you of the results when the investigations are completed.

IPSWICH.

FEB. 4, 1904.

To the Water Commissioners of the Town of Ipswich.

GENTLEMEN: — The State Board of Health, in accordance with your request for an examination of the storage basin of the public water supply of Ipswich, and advice as to improving the quality of the water, which has been affected at times by disagreeable tastes and odors, has examined the condition of the reservoir, and has made experiments during the past three years upon the purification of the water by intermittent filtration, using for this purpose two experimental filters constructed by you, which were well suited to the purpose. These filters contained above the underdrains about 5 feet of sand obtained in the neighborhood, and were operated at a rate of about 2,500,000 gallons per acre per day; the only difference in the operation of the two filters being that in one case the water was aerated before being applied to the filter, while in the other the water was applied directly as it came from the reservoir, but the effluent coming from this filter was aerated before being collected for analysis. A temporary filter was operated for a time at the town hall.

The water of Dow's Brook reservoir has been analyzed by the Board at frequent intervals since the reservoir was first used, in 1895; and an examination of the results of these analyses shows that this water has generally had but little color, and the quantity of organic matter present, while greater than found in some ponds and reservoirs, is not excessive.

The objectionable taste and odor of this water, which were the cause of much complaint in the earlier years and up to the time when these experiments were begun, were probably caused largely by the organisms which grow in abundance on the sides and bottom of the reservoir, especially near its upper end, and by microscopic organisms suspended in the water. The offensive taste and odor may have been due in part also to drawing water from the bottom of the reservoir, where, it is not improbable, a layer of stagnant water exists during the summer, as in many other ponds and reservoirs. During the time that these experiments have been continued the objectionable odor has apparently been less noticeable than in previous years, excepting in the early part of 1903, when the water had an offensive fishy and oily odor, due to the presence of the organism *Uroglena* in great numbers.

An examination of the results of the analyses of the water before and after filtration shows that the experimental filters operated in the manner described removed nearly all of the color from the reservoir water and a large portion of organic matter, and that the effluent was in all cases clear, nearly colorless and free from odor. During the time when the great quantity of *Uroglena* was present in the water, in the spring of 1903, the temporary filter set up in the town hall removed all of the taste and odor from the water during the short time when this water was affected by these organisms.

The results of the experiments and of investigations upon the purification of other waters similarly affected indicate that the objectionable taste and odor of the water of Dow's Brook reservoir can be removed, and the water made clear, odorless and practically colorless and satisfactory in all respects for domestic purposes, by filtration through sand at a rate as great as 2,500,000 gallons per acre per day.

Your attention was called by this Board in 1896 to the great danger of injury to the health of the people of the town by the pollution of the water of the reservoir and its tributaries by sewage and other wastes from the large number of dwelling houses and other buildings along its northwesterly side.

The results of a recent examination of this locality show that no material improvement has been made in these conditions, and that much sewage from the buildings referred to still finds its way into the reservoir.

It will be very difficult to prevent wholly the pollution of the reservoir from these buildings, but by filtering the water of the reservoir it will be practicable not only to greatly improve its quality and remove the disagreeable tastes and odors by which it is now at times affected, but also to protect the health of the town from the danger due to the pollution of the reservoir and its tributaries.

The Board would advise that filters be installed as soon as possible. The filters should be constructed under the direction of an engineer of experience in the design and construction of such works, and a sufficient area should be provided to allow for a considerable increase in the use of water by the town.

The Board will, upon application, advise you as to any plans for the purification of this water that you may desire to present.

LAWRENCE.

FEB. 17, 1904.

To the Lawrence Water Board, Lawrence, Mass.

GENTLEMEN: — The State Board of Health recognizes with great concern that the water of your reservoir is daily falling at such rate that if it continues two weeks longer there will arise the necessity of drawing water directly from the river without filtration, and thus repeating the terrible experience of Butler, Pa., with its 1,247 cases and 68 deaths by typhoid fever from a similar cause.

The danger to the health of the community requires the application of extraordinary means of protection.

If, after doing all that can be done to get purified water through the filter, the supply is but three-quarters as much as the people draw from the reservoir, every effort must be made to prevent so great a draft.

The Board advises that a notice be put in the hands of every water taker in the city, urging him or her to save all that is possible in daily use, and warning them that, unless they get on with three-quarters the amount generally used, the lives of the people will be in peril.

Beyond this the Board advises the employment of a competent body of men to make a rapid house-to-house inspection, and cause the stopping of all waste by leaking faucets or water-closets and running of water by night; in short, by taking every means in your power to prevent the draft being greater than the supply.

To accomplish this for a few weeks appears to be the only method within your system of water works of averting a calamity.

If you find that enough cannot be saved, it may be practicable to obtain some help by temporary connections with the water works of neighboring towns.

April 28, 1904.

To Hon. C. F. Lynch, *Mayor*, Mr. E. L. Arundel, *President of Water Board*, and Mr. M. F. Collins, *Superintendent of Water Works, Committee on Filter proposed by the International Sewage Disposal Company for the Water Supply of the City of Lawrence.*

Gentlemen: — The State Board of Health received from you on April 14, 1904, the following communication, submitting for the approval of this Board certain plans and specifications of a filter for the purification of the water supply of the city of Lawrence: —

At a meeting of the city council of this city, held March 7, a representative of the International Sewage Disposal Company was present, and made the following proposition: that the above-named company would construct a filter of one-half an acre for $30,000. This plant would filter 3,000,000 gallons per day, and the effluent to be satisfactory to the State Board of Health.

The board of aldermen, at a meeting held March 14, voted to have the above-named company draw plans and specifications for their proposed new filter, and submit the same to the water board and the committee on water works of the city council. The common council, at their meeting held March 21, concurred in the action of the board of aldermen.

On Monday, April 11, the water board and the committee on water works held a meeting in the common council chamber. Mayor Cornelius F. Lynch presided, and, after an examination of the plans and specifications prepared by the International Sewage Disposal Company, it was voted that a committee of three, consisting of Hon. C. F. Lynch, Mayor, E. L. Arundel, president of the water board, and M. F. Collins, superintendent of water works, present the above plans and specifications to the State Board of Health for their approval; accordingly, we are forwarding you to-day the plans and specifications under separate cover.

Any information in regard to the working details of the plans will be furnished by John H. French, general manager, and C. D. Mitchell, consulting engineer, of the International Sewage Disposal Company.

The plans and the description of the proposed water purification plant filed therewith provide for pumping water from the Merrimack River into four sedimentation tanks, having a capacity of 250,000 gallons, in which the water is to be allowed to settle for a period of two hours; and for filtering the water, after passing through the tanks, upon a filter composed of sand, gravel and broken stone, having an area of 22,200 square feet and a depth of 5 feet of filtering material, the whole to be enclosed in a building provided with skylights.

The proposed filter is to be composed of a bottom course of broken stone 6 inches to 8 inches in thickness, containing pipes passing longitudinally through the filter, which it appears are intended to allow the passage of air into the filter. Above this is a layer of gravel 2 inches in thickness; then a layer of sand, described as "clean, sharp" sand, 30 inches in thickness; then another layer of fine gravel; then a 6-inch layer of broken stone, including more aerating pipes, so called; then a layer of fine gravel 2 inches deep; and finally a layer of fine sand 12 inches deep.

The filter is at such an elevation that the water from the river would have to be supplied to it by pumping, and, after passing through it, would apparently flow freely into the present pump well at the pumping station at all times.

The Board has carefully considered the plans and specifications and the descriptions submitted therewith, and finds that, as a means of purifying the water of the Merrimack River and protecting the health of the people of Lawrence from typhoid fever and other evils resulting from the use of unpurified or imperfectly purified river water for drinking, the proposed filter would, in its judgment, be entirely inadequate and unsuitable; hence, the Board declines to approve the plans and specifications submitted.

JUNE 2, 1904.

To Hon. CORNELIUS F. LYNCH, *Mayor*, EDWARD L. ARUNDEL, *President of Water Board*, and M. F. COLLINS, *Superintendent of Water Works, Lawrence, Mass.*

GENTLEMEN: — The State Board of Health received from you on May 9, 1904, the following communication relative to a proposed plan of purifying 6,000,000 gallons per day of Merrimack River water for the supply of the city of Lawrence: —

Your communication of April 28, in reply to our request asking for your opinion on the plans and specifications of the International Sewage Disposal Company, was read and accepted at a joint meeting of the water board and the committee on water works of the city council, held May 6.

At this meeting Mr. Chipman of the Chipman Electric Purifying Company of New York appeared, and made the following proposition: that his company would install a plant to purify 6,000,000 gallons per day, to include a 200 horse-power boiler; a 65 horse-power engine; a 50-kilowatt generator; three 2,000,000-gallon centrifugal pumps; switch boards, meters, etc.; three basins for purifying, 20 by 6 by 3 feet in size; three basins for clarifying, 30 by 6 by 4 feet in size; 180 electrodes, 6 by 3 feet by $\frac{7}{16}$ inch; 24 feet of 18-inch pipe laid; and 30 12-inch gate-valves, ready for use. All these would be furnished for approximately $20,000, exclusive of a building.

The cost for maintenance would be about $3,000 per year, $1,596 of which would be for additional electrodes. The water, which would be guaranteed to be clear and free from disease germs, and not over 2 per cent. in hardness, would cost approximately $2.55 per million gallons.

Mr. Chipman informed the committee that he would furnish bonds to the amount of the cost of the plant.

We were instructed to present the proposition of Mr. Chipman to the State Board of Health for their approval.

Owing to the short time that remains before the General Court adjourns, the committee feels that as prompt reply as would be consistent for your honorable body to give the proposed plans your due consideration would be appreciated.

Subsequently a model of the proposed purifying plant was delivered at the office of the Board by an agent of the Chipman Electric Purifying Company, and on May 19 the plans of the proposed works for purifying the water supply of the city of Lawrence were filed in this office.

Since the receipt of the model the Board has conducted experiments upon the effect of treating sewage-polluted water in the manner outlined in the plans and descriptions submitted by the Chipman Electric Purifying Company, and has carefully examined the plans of the proposed works and the information submitted therewith.

The essential features of the plans submitted are: (1) a receiving basin, so called, in which the water of the river will be received, and opportunity allowed for sedimentation; (2) purifying basins, through which the river water is to flow, containing electrodes composed chiefly of aluminum, through which an electrical current is to be passed; and (3) clarifying basins, so called, in which are four compartments, arranged transversely across the basin, which are to contain quartz or charcoal 2 feet in thickness, through which the water is expected to pass and be clarified, the arrested matter being discharged from the basin at intervals through outlets in the bottom. The water is expected to pass successively through these four filters or strainers, each 2 feet in thickness, and having an area of about 180 square feet.

The results of experiments upon the removal of sediment from the water of the Merrimack River at Lawrence by means of sedimentation basins show that very little of the organic matter in the river water would be removed in the proposed receiving basin. Experiments with the model submitted show that the bacteria in the water would be only partially removed by the electrical process proposed, which is, in effect, chemical precipitation. In order to pass the water through the filters in the clarifying basins at the rate indicated, it would be necessary that they should be composed of exceedingly coarse material, which would preclude their operating efficiently as filters. The cost of operating such a plant, judging from the information available to the Board, would be many times greater than the cost of operating an ordinary sand filter.

In the opinion of the Board, the proposed electrical treatment would not destroy the harmful bacteria in the water, and a subsequent thorough filtration of the water would be necessary in order to effect its purification. Such filtration would not be accomplished by the proposed strainers.

Works constructed in accordance with the plans submitted would, in the opinion of the Board, be incapable of protecting the health of the people of Lawrence from the effect of a polluted drinking water, and the Board declines to approve the proposed plans.

LAWRENCE (WELL AT CITY HALL).

JUNE 2, 1904.

To the Board of Health of the City of Lawrence, MR. ROSCOE DOBLE, *Clerk.*

GENTLEMEN: — In response to your request for an examination of the water of a well at the city hall in Lawrence and advice as to its quality, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water, though nearly clear and but slightly colored, is badly polluted, and a bacterial examination shows the presence of bacteria characteristic of sewage.

In the opinion of the Board, the use of water from this well would be liable to cause sickness, and the Board would advise that the possibility of the future use of this water for drinking be prevented.

LAWRENCE (BRIGGS & ALLYN MANUFACTURING COMPANY).

MARCH 3, 1904.

To the Briggs & Allyn Manufacturing Company, Lawrence, Mass., MR. LEWIS P. COLLINS, *Agent.*

GENTLEMEN: — The State Board of Health received from you on Nov. 2, 1903, a communication requesting advice as to the quality of the water of a tubular well 195 feet deep, recently sunk on your premises at Lawrence, from which you propose to take water for drinking if the quality is found satisfactory; and in response to your request the Board has caused the well and its surroundings to be examined and several samples of the water to be analyzed chemically and bacterially.

The results of the analyses show that the water has at some time been slightly polluted, but subsequently well purified in its passage through the ground before entering the well; and the Board is of the opinion that while its condition remains as at present this water may safely be used for drinking. The water should be analyzed from time to time, however; and if deterioration occurs, its use should be discontinued.

LENOX.

JULY 7, 1904.

To Mr. WILLIAM D. CURTIS, *Treasurer, Lenox Water Company, Lenox, Mass.*

DEAR SIR: — The State Board of Health has considered your communication of June 21, 1904, in which you state that organisms have reappeared in the storage reservoir from which the supply of Lenox is drawn, causing the water to have a very disagreeable taste and odor, and requesting advice as to whether this Board will recommend the application of sulphate of copper to this reservoir for the prevention of the trouble.

The method of treatment proposed has only recently been suggested as a possible means of removing the disagreeable tastes and odors caused by the presence of *Algæ* and similar water plants in the waters of ponds and reservoirs; and the tests which have thus far been made, in co-operation with the United States Department of Agriculture, have not been carried far enough to enable the Board to advise you either as to the efficacy of this treatment in preventing troubles from tastes and odors in your reservoir water, or as to what effect, if any, this method of treatment of a water supply reservoir might have upon persons or animals using the water for drinking.

The statement contained in your letter, that in one place where this method has been tried a certain kind of fish was killed, serves to indicate some of the objections to the use of this method until its effects have been well determined by experiments with ponds and reservoirs not used as sources of drinking water supply.

Experiments have shown that it is practicable to purify waters affected by disagreeable tastes and odors, such as render the water of the Lenox reservoir objectionable, by filtering the water through sand; and this method has the further advantage in this case, that, if properly carried out, it will prevent danger of injury to the health of those who use the water for drinking, which might now be caused by pollution finding its way into the water from the farm buildings and cultivated lands on this water-shed.

The Board believes that in the case of the Lenox reservoir filtration of the water will be, all things considered, the best practicable method of preventing the disagreeable tastes and odors caused by organisms, and the danger arising from possible pollution of the water from the buildings within the water-shed.

LENOX (NEW YORK, NEW HAVEN & HARTFORD RAILROAD COMPANY).

SEPT. 1, 1904.

To the Superintendent of the Berkshire Division of the New York, New Haven & Hartford Railroad Company.

DEAR SIR: — In response to the request of Mr. H. W. Fenn, agent at the Lenox station of the New York, New Haven & Hartford Railroad Company, for advice as to the probable effect of proposed works for the disposal of the sewage of Lenox, located near the present source of water supply of the station, upon the quality of the water, the Board has caused the locality to be examined by one of its engineers and has caused samples of the water to be analyzed.

It appears that the supply is now drawn from a spring, so called, near a brook flowing near the sewage disposal area of the town of Lenox, the water being evidently derived, in part at least, from the brook.

Analyses of the waters of the spring and brook indicate that they have been slightly polluted, but it does not appear that the sewage or effluent from the Lenox sewage disposal works was finding its way into your source of supply at this time. The proposed new filters, if underdrained so as to convey the effluent away from the neighborhood of the brook, would probably not affect your water supply; but if the lands near the northerly limit of the area owned by the town, which appear to contain better soil for sewage disposal than other parts of the area, should be used, the Board is of the opinion that your source of water supply might be affected.

LONGMEADOW.

APRIL 7, 1904.

To the Board of Water Commissioners of the Town of Longmeadow.

GENTLEMEN: — The State Board of health received from you on March 28, 1904, a petition for the approval by this Board of the taking of certain lands in Longmeadow for the protection of the water supply of the town, accompanied by a plan and description of the proposed takings, and the Board has caused the locality to be examined by one of its engineers and has considered the plan of these areas presented.

The areas indicated, with the exception of very small portions, are within the water-shed of Cooley Brook, from which the water supply of Longmeadow is now drawn; and, in the opinion of the Board, it is essential that the town should control these areas in order to adequately protect its source of water supply; and the Board hereby approves the taking by the town of Longmeadow of the lands shown upon the plan submitted with this application, said lands being bounded, measured and described as follows: —

Daniel Castle Tract.

Beginning at a point in the northerly line of the Bliss Road, and at the division line of land of Daniel Castle and Harriet M. Bliss, and running thence north-easterly along said division line about 786 feet to the land of Ethan Ely.

Thence south-easterly along division line of land of Ethan Ely and Daniel Castle about 997 feet to a point.

Thence southerly along the division line of land of Ethan Ely and Daniel Castle about 415 feet to the northerly line of the Bliss Road.

Thence westerly along the northerly line of the Bliss Road about 1,190 feet to the point of beginning.

The above-described parcel of land contains about 15.45 acres.

Ethan Ely Tract.

Beginning at a point on the division line of land of Judge Patrick Casey, heirs G. Hooker and Ethan Ely, and running thence easterly on the continuation of the division line of land of said Casey and Hooker about 1,560 feet to a point.

Thence southerly on land of said Ethan Ely about 968 feet to land of Daniel Castle.

Thence north-westerly along division line of land of said Daniel Castle, Ethan Ely and Harriet M. Bliss, about 1,837 feet to a point on the division line of lands of said Ethan Ely, Harriet M. Bliss and town of Longmeadow.

Thence northerly along division line of lands of said Ethan Ely, town of Longmeadow and heirs of G. Hooker, about 421 feet to the point of beginning.

The above-described parcel of land contains about 24.63 acres.

Heirs of George Hooker Tract.

Beginning at a point on the division line between land of heirs of G. Hooker and land of town of Longmeadow, said point being about 275 feet distant easterly from the easterly line of Main Street, and running thence northerly about 336 feet on land of said Hooker to a point on division line between land of said Hooker and land of Judge Patrick Casey, said last-mentioned point being distant about 294 feet easterly from the easterly line of Main Street

Thence easterly along division line of lands of said Casey and said Hooker about 1,080 feet to a point, said point being at the division line of lands of said Hooker, Casey and Ethan Ely.

Thence southerly along division line of lands of said Hooker and Ely about 320 feet to a point in the division line of lands of said Hooker, Ethan Ely and town of Longmeadow.

Thence westerly along division line of lands of said Hooker and said town of Longmeadow about 1,215 feet to the point of beginning.

The above-described parcel of land contains about 8.24 acres.

Martha B. and Mary E. Cooley Tract.

Beginning at a point in the division line of land of town of Longmeadow and land of Martha B. and Mary E. Cooley, said point being distant easterly about 690 feet from the easterly line of Main Street, and running thence easterly along division line of land of said town of Longmeadow and land of said Cooley about 735 feet to a point, said point being at the division line of land of said town of Longmeadow, Cooley and Harriet M. Bliss.

Thence south-westerly along division line of said Harriet M. Bliss and Cooley about 360 feet to a point in said division line.

Thence north-westerly along said division line about 625 feet to a point.

Thence northerly on land of said Cooley about 420 feet to the point of beginning.

The above-described parcel of land contains about 6.27 acres.

Harriet M. Bliss Tract.

Beginning at an angle point in the northerly line of the Bliss Road, and running thence northerly on land of Harriet M. Bliss about 467 feet to a point.

Thence north-westerly and in range with the southerly division line of land of Martha B. and Mary E. Cooley and Harriet M. Bliss about 500 feet to a point at the south-easterly corner of said Cooley land.

Thence northerly along division line of land of Harriet M. Bliss, Cooley and town of Longmeadow, about 767 feet to a point on the division line of land of Ethan Ely, Harriet M. Bliss and town of Longmeadow.

Thence south-easterly along division line of land of Ethan Ely and Harriet M. Bliss about 840 feet to a point in the division line of land of Ethan Ely, Daniel Castle and Harriet M. Bliss.

Thence south-westerly along division line of land of Daniel Castle and Harriet M. Bliss, about 786 feet to the northerly line of the Bliss Road.

Thence westerly along the northerly line of the Bliss Road about 26 feet to the point of beginning.

The above-described parcel of land contains about 10.44 acres.

The examination made by the Board shows that there are buildings within the water-shed of the brook not included in these takings; and it is very desirable, in the opinion of the Board, that the town should secure control of such further areas within the water-shed of this brook as are liable to become inhabited.

MAYNARD.

FEB. 4, 1904.

To the Board of Water Commissioners and the Board of Health of the Town of Maynard.

GENTLEMEN: — The State Board of Health is informed that water for the supply of Maynard has been drawn at times during the past year from a brook flowing near your pumping station, at a point a short distance above the place where this stream joins the Assabet River.

The Assabet River at Maynard is seriously polluted by sewage, and there is great danger that in drawing water from the brook, polluted river water may, under some conditions, be drawn into your water supply system.

If the supply of water from White Pond, the source now used, is inadequate, or if the pipe which conveys the water is too small for the requirements of the town, an adequate supply of good water should be provided without delay.

FEB. 4, 1904.

To the Board of Health of the Town of Maynard.

GENTLEMEN: — Your attention is called to the fact that, while water from the Maynard water works is supplied for drinking in the mills of the American Woolen Company, the polluted water of the Assabet River is also supplied for washing and other purposes in these mills; and that the faucets of the two systems are in many places side by side or close together, with no adequate means by which the operatives may distinguish between the town water and the polluted river water.

An examination of the causes of an exceptionally large number of cases of typhoid fever among the operatives in these mills recently showed that the disease was probably caused by the drinking of polluted river water supplied in these mills. The Board would advise that, if it is necessary that river water shall be provided in these mills where it may be used for drinking, the faucets through which it is supplied should be marked in such a way that they may be readily distinguished from those connected with the town supply; and the operatives and others who have access to them should be instructed as to the danger of using the water from faucets connected with the river supply for drinking.

MERRIMAC.

MARCH 3, 1904.

To Messrs. EVERETT D. GEORGE, FRANK E. PEASE and WILLIAM L. SMART, *Board of Water Commissioners of the Town of Merrimac.*

GENTLEMEN: — The State Board of Health received from you on Feb. 23, 1904, an application for the advice and approval of this Board, under the provisions of chapter 281 of the Acts of the year 1903, of a proposed source of water supply, which is described in your application as follows: —

> It is proposed to develop a ground water supply at "The Plains." Wells have been driven at this place, sixteen of which have been connected together and to a steam pump. A pumping test of two weeks' duration has been made on these wells, and observations were taken during the pumping test on six other wells driven in different locations in the vicinity, but not connected with the pump. In the final plan of construction it is proposed to use the sixteen wells which were connected to the pump, driving others if it is necessary to obtain a sufficient supply.
>
> It is proposed to locate the pumping station at such a point that water can be drawn from Kimball's Pond by suction and pumped upon the land in the vicinity of the wells, with a view of increasing the supply by natural filtration through the ground, if the growth of the town and the consumption of water demand in future a greater supply than that naturally furnished by the wells. This water will be pumped into a stand-pipe which will be covered to exclude the light.
>
> The location of the wells already driven is shown on a plan accompanying this application.

The Board has already considered the proposed source and the information available concerning the quantity and quality of water to be obtained therefrom, in response to an application of a water supply committee of the town; and on Jan. 7, 1904, advised the committee as follows: —

> The Board has carefully examined the plans and information submitted therewith, and the results of analyses of numerous samples of water collected before and during the pumping test.

The information submitted to the Board shows that water was pumped continuously from the wells at a rate of not less than 300,000 gallons per day for a period of two weeks, and that during this time the water in the ground about the wells lowered less than 2 feet, and less than a foot in any of the test wells in which measurements were made; and considering the circumstances, the Board is of the opinion that an adequate supply of water for the present requirements of Merrimac can be obtained from the ground where this test was made.

It is probable that a larger supply could be obtained, if necessary, by extending the wells over a somewhat larger area; though care will be necessary, in locating new wells, to avoid using wells in localities containing an excessive quantity of organic matter or iron. If in future, on account of the growth of the town or increase in the use of water, a larger supply is found necessary than wells in this locality are capable of furnishing, a larger supply can doubtless be obtained without special difficulty by filtering the water of Kimball's Pond, either in the manner proposed in your application or by some other plan.

The quality of the water of the test wells, as shown by the results of analyses of numerous samples collected during the pumping test, is excellent for all the purposes of a public water supply; and, if the water shall be kept from exposure to light until delivered to consumers, as proposed in your plan, its quality should remain satisfactory.

In the opinion of the Board, the information furnished by your recent tests shows that a sufficient supply of good water for the town of Merrimac can be obtained from the ground at the locality in which the recent tests were made, and the Board approves the adoption of this source.

The Board hereby approves the use of the proposed source of water supply for Merrimac, under the provisions of chapter 281 of the Acts of the year 1903.

MILLBURY (E. G. HOWE).

JULY 7, 1904.

To MR. E. G. HOWE, *Millbury, Mass.*

DEAR SIR: — In response to your request for an examination of a spring in Millbury from which you are taking water to sell for drinking, the Board has caused the spring and its surroundings to be examined and samples of the water to be analyzed.

The results of the recent analyses show, when compared with analyses made in previous years, that very little change has taken place in the quality of the water, and, in the opinion of the Board, this water is safe for drinking at the present time.

The Board would advise that the pump which has already been connected with the spring be used in the filling of all receptacles in the future, and the possible danger of the contamination of the spring, caused by the present method of collecting the water, avoided.

It is also desirable that further provision be made to prevent the entrance of surface water from the driveway above the spring, since it is possible that, at times of very heavy rain, water from this driveway might find its way into the spring.

By making the changes suggested, the water of this spring may, in the opinion of the Board, safely be used for drinking while the conditions about it remain as at present.

MILTON (HOUGHTON SCHOOL).

NOV. 3, 1904.

To the Board of Health of the Town of Milton, DR. A. W. DRAPER, *Secretary*.

GENTLEMEN: — In accordance with your request of October 20 for an examination of the well at the Houghton school, and advice as to the quality of the water, the Board has caused the well to be examined and samples of the water to be analyzed.

The well is situated in the lower part of the grounds, while the school and its outbuildings are in the higher portions. The water when examined had a disagreeable odor, and the chemical and bacterial analyses show that it is evidently being polluted.

In the opinion of the Board, the water is unsafe for drinking, and its further use as a source of drinking water supply should be prevented.

MILTON (LEOPOLD MORSE HOME).

DEC. 1, 1904.

To the Trustees of the Leopold Morse Home, Mattapan, Mass., MR. SOLOMON SCHINDLER, *Superintendent*.

GENTLEMEN: — In response to your request for an examination of the water of a well upon the grounds of the institution at Mattapan, and advice as to the quality of the water, the Board has caused an examination of the well to be made and a sample of the water analyzed.

The water is turbid, has an unpleasant odor, and has evidently been considerably polluted by sewage and not well purified in its subsequent passage through the ground. There are sources of pollution in the neighborhood of the well, and, in the opinion of the Board, the water is unsafe for drinking.

NORTHAMPTON.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on June 2, 1904, for preventing the pollution and securing the sanitary protection of the sources of water supply of the city of Northampton.

NORTH ATTLEBOROUGH.

JULY 7, 1904.

To the Board of Water Commissioners of the Town of North Attleborough.

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to increasing the water supply of North Attleborough by taking water from a large dug well, to be located near the Ten Mile River in Wrentham below Fuller Street, and has caused the locality to be examined by one of its engineers and samples of water from test wells in this region to be analyzed.

The information furnished to the Board concerning the test wells recently driven in the valley of the brook below Fuller Street indicates that strata of fine material were encountered in many of these wells, and that ledge is found not far beneath the surface; so that the indications furnished by many of these wells are unfavorable to obtaining water freely from the ground in such quantities as would be necessary for the supply of North Attleborough.

The most favorable conditions were found in two test wells located a little more than half a mile below Fuller Street on the easterly side of the railroad, near the brook, a short distance below the site of an abandoned dam. The material encountered at this place was coarse and porous to a considerable depth, and water could be pumped from these wells very freely.

Samples of water collected and sent in by you from the various wells all contained considerable quantities of clay and sand; and it is impracticable to determine satisfactorily from these samples the probable quality of the water obtainable from the ground in this region, though the results indicate that the water would be of good quality unless it should be affected by an excess of iron.

The Board would advise that additional wells be put in in the neighborhood of the test wells located near the old dam, and that a pumping test be made by pumping from these wells for a period of a week or more at a rate at least as great as would be required for the supply of North Attleborough; and that observations be made, during this test, of the effect of the pumping upon the height of the ground water in the neighborhood of the wells. Samples of water should also be taken from time to time during the test, in order to determine its probable quality.

The Board will assist you in these investigations, if you so request, by making the necessary analyses of samples of water, and will give you further advice when the results of further tests are available.

Sept. 1, 1904.

To the Water Commissioners of the Town of North Attleborough, Mr. J. F. Makinson, *Chairman.*

Gentlemen: — The State Board of Health received from you on Aug. 18, 1904, an application for advice with reference to a proposed additional water supply for the town of North Attleborough, accompanied by a statement of the results of further tests of the ground in the neighborhood of the Ten Mile River above the village of Plainville in Wrentham, as advised by the Board in response to your previous application. The tests are described in your application as follows: —

> The town of North Attleborough is about completing a pumping test from 13 2-inch driven wells, averaging 25.8 feet deep. Pumping was begun Aug. 5, 1904,

> and has been continuous since the morning of August 6. It is proposed to close the test at 5 P.M. to-day, August 17, a total of about two hundred and seventy-four hours.
>
> The pumpage at the start was at the rate of about 370,000 gallons per twenty-four hours, but has been increased, so that for the latter part of the test it has been at the rate of 738,000 for several days.
>
> Readings of the depth over a 30-inch weir have been taken every fifteen minutes. Records of the height of the water in an observation well, located in the immediate vicinity of the 12 wells pumped from, have also been made. At the beginning the water stood 15¾ inches below the top of the pipe of the test well, which is 14¾ inches above the surface of the ground; at the close of the test the water stood 49½ inches below the top of the pipe.
>
> The temperature by a standard thermometer, at 10 A.M , August 15, of the water at the weir tank, was 51°; Ten Mile River at same time, 59°; air, 80°.
>
> Samples of water from the weir tank, representing a mixture from all the 12 wells, have been sent you for analysis every day.

Several samples of water collected and sent in by you from time to time during the test have been analyzed by the Board, and the Board has also caused the locality to be examined by one of its engineers.

The results of observations upon the height of water in a well near the test wells show that the ground water went down rapidly in the beginning of the test, but more slowly later, even when a larger quantity of water was being drawn, and the recovery of the water after pumping had ceased was rapid; and, judging from the results of the observations submitted, the Board is of the opinion that it is practicable to obtain from the ground at this place a large quantity of water, sufficient to meet the requirements of North Attleborough in the matter of water supply for a long time in the future, unless the increase in the use of water shall be at a materially greater rate than in the past ten years.

The results of the analyses of samples of water collected during the test show that the water is clear, colorless and odorless, and otherwise of excellent quality for the purposes of a public water supply. A portion of the test wells, however, were located in the low land close to the brook, where there is in some places a depth of several feet of mud. It will be necessary, in order to avoid danger of deterioration in the quality of the water, to locate the permanent works in the upland farther from the stream, and this can be done without special difficulty.

While the wells are located at no great distance from the village of Wrentham, it is unlikely that the quality of the water will be noticeably affected by sewage discharged upon or into the ground in this village, unless the territory nearer the wells should become populated. If the village should have a tendency in the future to grow in the direction of the wells, it would be desirable for the town of North Attleborough to secure control of lands in the neighborhood of the wells before the region becomes more thickly populated.

In the opinion of the Board, water of excellent quality can be obtained from the ground, in the locality in which the recent tests were made, by means of tubular wells or other suitable works, and the quantity obtainable would form a large addition to the available water supply of the town.

NORTHBOROUGH (ALMSHOUSE).

MAY 5, 1904.

To the Board of Selectmen and Overseers of the Poor, Northborough, Mass.

GENTLEMEN: — In accordance with a request of the State Board of Charity for an examination of the condition of a well used as a source of water supply at the almshouse in Northborough, the State Board of Health has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that this water is very foul, having evidently been grossly polluted by sewage from the house, and probably also by foul drainage from other sources in the neighborhood.

The Board would advise that the possibility of further use of water from this well for any purpose be prevented, and that a supply of water be provided from an unpolluted source.

PEABODY.

MAY 5, 1904.

To the Committee on Water Supply of the Town of Peabody, Mr. H. F. WALKER, *Chairman.*

GENTLEMEN: — In response to your request for the consent and approval of the State Board of Health, under the provisions of chapter 185 of the Acts of the year 1904, for the taking of certain lands bordering Spring Pond in the town of Peabody, the Board, in accordance with the provisions of the above-mentioned act, gave a public hearing at its office, room 141, State House, on Thursday, April 28, 1904, notice of which was given by publication in a newspaper published in the city of Salem.

After this hearing the Board voted to approve the taking of certain lands in the water-shed of Spring Pond in the town of Peabody, described as follows: —

Estate of R. S. Fay, Grantor. Town of Peabody, Grantee.

A certain parcel of land situated in Peabody, and bounded and described as follows: —

Beginning at a point at the angle of Spring Pond dam, so called, and running N. 24° 10′ W. by land of grantee fifty-five feet more or less to a stone wall; thence N. 76° 10′ W. along said wall by land of Wm. Brown two hundred thirty-three feet more or less; thence S. 33° 20′ W. by land of grantor nine hundred seventy feet more or less to a point on a stone wall; thence S. 76° 25′ E. along said wall by land of F. L. Newhall a distance of one hundred and sixty feet more or less to the shore of Spring Pond; thence north-easterly along shore of said pond to the point of beginning, and containing three and eighty-two one hundredths (3.82±) acres more or less.

Estate of F. L. Newhall, Grantor. Town of Peabody, Grantee.

A certain tract or parcel of land situated in the town of Peabody, and bounded and described as follows: —

Beginning at a stone monument on the west shore of Spring Pond, which is the intersection of the division lines between the town of Peabody and the cities of Lynn and Salem, and running along a stone wall between said Lynn and Peabody a distance of two hundred and seventy feet more or less by land of R. S. Fay and Isaiah Graves; thence N. 24° 10′ W. by land of grantor a distance of five hundred ninety-three (593±) feet more or less to a point; thence N. 72° 35′ E. by land of grantor nine hundred thirty feet more or less to a point; thence N. 80° 35′ E. by land of grantor a distance of four hundred forty-four (444±) feet more or less to a point on a stone wall; thence S. 76° 25′ E. along said wall by land of now or formerly R. S. Fay a distance of one hundred sixty (160±) feet more or less to the shore of Spring Pond; thence along the shore of Spring Pond in a south-westerly and south-easterly direction to the point of beginning; and containing twelve and nine-tenths (12.9±) acres more or less.

PEABODY (F. T. MOORE).

OCT. 6, 1904.

To MR. F. T. MOORE, *589 Essex Street, Lynn, Mass.*

DEAR SIR: — In response to your request of August 31 for an examination of the water of a well on Lowell Street in West Peabody, from which you state it is your intention to sell water for drinking and family use if the quality is satisfactory, the State Board of Health has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of this analysis show that the water has at some time been polluted, and has not been purified before entering the well, the sample containing a larger quantity of organic matter and a larger number of bacteria than are found in ground waters from unpolluted regions. There are buildings in the immediate neighborhood of the well from which the pollution is evidently derived, and, in the opinion of the Board, this well is not a safe source of water supply.

PLYMOUTH.

FEB. 4, 1904.

To the Board of Water Commissioners of the Town of Plymouth.

GENTLEMEN: — In response to the request from your office received January 11, for an examination of the water of Great South, Little South and Lout ponds, which you state is at present affected by a bad taste and odor, and advice as to its quality, the Board has caused the sources mentioned to be examined and samples of their waters to be analyzed.

The results of the analyses show that the offensive taste and odor of the water at the present time are due to the presence of the organism *Uroglena* in the waters of Little South and Lout ponds. The cause of the appearance of this organism in water is not known, and the Board knows of no practicable method of preventing its appearance and growth in the waters of ponds and reservoirs used as sources of public water supply. Water containing this organism is not known to be dangerous to health if used for drinking, but the offensive fishy and oily odor which the organism imparts to water frequently renders it unfit for this purpose.

In response to an application from the water commissioners of Plymouth in 1895 for advice as to the best method of preventing the objectionable conditions resulting from the presence of this organism in the water supply of Plymouth, and of improving the quality of the water, the Board advised that the conditions in the vicinity of the ponds from which your present supply is drawn appear to be favorable for obtaining water freely from the ground by means of wells or filter-galleries, and advised that you make an investigation as to the practicability of obtaining a water supply for the town by this plan and avoid the direct use of water from the ponds. A copy of this communication is enclosed herewith.

The Board would again advise that you investigate the practicability of securing a supply of ground water for the town, and avoid the frequent trouble from offensive tastes and odors in the water supply of the town, resulting from the presence in the water of *Uroglena* and other organisms.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on May 5, 1904, for preventing the pollution and securing the sanitary protection of the sources of water supply of the town of Plymouth.

Randolph and Holbrook.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on July 7, 1904, for preventing the pollution and securing the sanitary protection of the waters of Great Pond and its tributaries, used by the towns of Randolph and Holbrook as a source of water supply.

Shelburne.

July 7, 1904.

To the Committee on Water Supply of the Shelburne Falls Fire District, Mr. W. S. Ball, *Chairman.*

Gentlemen: — The State Board of Health has considered your application for advice with reference to the use of Clark Brook in the town of Buckland as a source of water supply for the Shelburne Falls Fire District, and has caused the water-shed of this stream to be examined by one of its engineers and several samples of the water to be analyzed.

The water, as shown by these analyses, is naturally of good quality for the purposes of a public water supply, but the water-shed of the brook is found, upon examination, to contain several groups of farm buildings, some of which are located close to the stream; and if this brook should be used as a source of public water supply, it would be difficult to prevent the pollution of the water by sewage and other wastes from these buildings. If the buildings nearest the stream and its tributaries should be secured by the fire district, which might perhaps be done at a reasonable expense, the Board is of the opinion that this stream could safely be used as a source of public water supply.

No definite information is available as to the flow of Clark Brook in the drier portion of the year; but it appears, from an examination of the water-shed, that it is practicable to build a reservoir of considerable size in this valley if necessary, and an adequate supply of water for Shelburne Falls can evidently be obtained from this water-shed.

In view of the possible objections to the use of Clark Brook as a source of public water supply, the Board has caused examinations to be made of other streams in the neighborhood of Shelburne Falls.

Examinations of the waters of Wilder River, so called, in the town of Colrain, show that the water of this source is much softer than that of Clark Brook or any of the other brooks that were examined in this region; but this water-shed also contains a considerable population, and the source has the disadvantage that it is located at a considerably greater distance from the village than is Clark Brook.

Dragon and Sluice brooks in Shelburne were also examined, Sluice Brook having a decided advantage over Dragon Brook in the quality of its water and in other respects. The water-shed of Sluice Brook contains about the same population as that of Clark Brook; but the buildings are situated at greater distances from the streams, and the water could probably be protected from pollution with less difficulty and expense than in the case of Clark Brook. The area of the water-shed is about the same as that of Clark Brook, but the stream is about three-fourths of a mile farther from the village.

A tributary of Bear River in the southerly part of Buckland was also examined. The waters of this stream might be taken at a point above a highway in the north-easterly part of the town of Ashfield, and the drainage area above this point is somewhat greater than that of Clark Brook. The water-shed of the stream contains but three dwelling houses, which are located well away from the streams, and this water-shed could be more easily protected from pollution than any of the others examined. Its water is of about the same quality as that of Clark Brook, but the distance from the village is greater, and a pipe line about one and three-fourths miles longer would be required if this source should be used.

The Board is of the opinion that Clark Brook would be an appropriate source of supply for Shelburne, provided the dwelling houses and buildings which are located near the streams in this water-shed could be purchased and removed, and danger of pollution from these places prevented; and, in estimating the cost of a supply from this source, the cost of the purchase and removal of these buildings should be included. Under the circumstances, the cost of a supply from this source might be greater than the cost of a supply from the tributary of Bear River or from Sluice Brook; and the Board would advise, therefore, that a careful estimate be made of the probable cost of works from each of those sources, including the probable cost of adequate protection of the waters from pollution.

When the results of further investigations are available the Board will, upon application, give you further advice in this matter.

SHREWSBURY.

MAY 5, 1904.

To Messrs. H. A. MAYNARD, R. E. ALLEN and W. H. RICE, *Water Commissioners of the Town of Shrewsbury.*

GENTLEMEN: — In response to your request of April 21 for the approval by this Board of a certain source of water supply for the town of Shrewsbury, the Board has caused the source indicated by you — a well located in the rear of one of the schoolhouses and near the public library in Shrewsbury — to be examined by one of its engineers and a sample of the water to be analyzed.

It appears from the information available to the Board that this well was sunk chiefly in rock, and the conditions are such that it is very doubtful whether the quantity of water which the source will yield would be sufficient for the requirements of the village in the drier portions of the year.

The results of an analysis of a sample of the water of the well show that it contains an excessive quantity of iron, which would make it very objectionable for many domestic purposes, and that it has been polluted by sewage and not thoroughly purified; and the Board does not approve the use of this well as a source of water supply for Shrewsbury.

There are several localities in the neighborhood of the village from which it may be practicable to obtain an adequate supply of good water by means of tubular wells, and the Board would advise that further tests be made, with a view to obtaining a supply of good water from the ground. It is not advisable to attempt to secure water by sinking wells in rock or in very compact soil.

SOMERVILLE (M. W. CARR & CO.).

OCT. 6, 1904.

To Messrs. M. W. CARR & CO., *Somerville, Mass.*

GENTLEMEN: — In response to your request for an examination of the water of a cistern and two tubular wells located at your factory, from which water is used for drinking and other purposes, the State Board of Health has caused the sources indicated to be examined and samples of their waters to be analyzed.

The large well is used as a cistern for the storage of roof water, and when examined evidently contained much rain water. The water was found to contain an excessive quantity of organic matter, and is not, in the opinion of the Board, suitable for drinking.

The tubular wells are located in a populous region, and the water has at some time been considerably polluted; and, although well purified in its subsequent passage through the ground, it is very hard, and is not a desirable drinking water. The quality of such waters is liable to deteriorate with a change in the conditions affecting their pollution, and the Board cannot advise the use of these wells as sources of drinking water supply.

Springfield.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on June 2, 1904, for preventing the pollution and securing the sanitary protection of the waters of Jabish, Broad and Axe Factory brooks, Ludlow reservoir, Chapin and Five Mile ponds and their tributaries, used by the city of Springfield as sources of water supply.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on Nov. 3, 1904, for preventing the pollution and securing the sanitary protection of the waters of Higher Brook and the lower basin of Van Horn reservoir and their tributaries, used by the city of Springfield as sources of water supply.

July 7, 1904.

To the Board of Water Commissioners of the City of Springfield, Mr. C. L. Goodhue, *Chairman.*

Gentlemen: — The State Board of Health has considered your application of June 20 for information as to the quality of the waters of Chapin and Five Mile ponds in the city of Springfield, and advice as to whether these ponds are suitable for use as sources of water supply for the city at the present time, and has caused the ponds and their surroundings to be examined by its engineer.

These ponds have already been used as sources of water supply for the city of Springfield from time to time for several years, and many analyses of their waters have been made during the last seven years, the results of which show that the waters of both sources are soft and nearly colorless, and otherwise naturally of good quality for the purposes of a public water supply.

Experience in the use of these waters has already shown that they are affected occasionally by disagreeable tastes and odors, due to the presence of certain microscopic organisms which are present at times in considerable numbers in these waters; but waters affected in this way are not known to be injurious to health when used for drinking or cooking.

Each of these ponds is situated in a sandy plain, and the limits of their water-sheds are indefinite. The water-shed of Chapin Pond may possibly contain one dwelling-house; but the circumstances are such that it is improbable that polluting matters deposited in or upon the ground at this place could find their way into the pond, unless by percolation for a long distance through the ground, in which case they would undoubtedly be thoroughly purified.

The only danger of pollution to which this source appears to be exposed at the present time is that which may be caused by visitors, chiefly in the summer season, who resort to the pond for bathing, fishing, etc.; and danger of the pollution of the water from this cause can be prevented without difficulty.

The water-shed of Five Mile Pond contains two dwelling houses, and it is possible that the ground water from the neighborhood of a third dwelling house, including adjacent barns and out-buildings, may percolate toward the pond. When the two dwelling houses nearest the pond were examined, the sewage and drainage were being cared for in vaults and cesspools; and the conditions are such that it is improbable that polluting matters from these premises find their way into the pond, unless by percolation through the ground, in which case they would undoubtedly be well purified before entering the pond. Drainage from the third dwelling house, together with the out-buildings, if it enters the pond at all, must percolate for a much longer distance through the ground than from the other two places. There appears to be no danger, under present conditions, of the pollution of the pond from any of these premises in such a manner as to render the water injurious or unsafe for drinking.

The arm of the pond near which the dwelling houses are situated is shallow, and contains a considerable growth of lilies and other organic matters, which doubtless have an unfavorable effect upon the quality of the water; and it is desirable to cut off this arm from the remainder of the pond by means of a dike, as you have suggested.

There is a picnic ground upon the shore of Five Mile Pond, and the pond is used to some extent as a resort for boating and fishing; and the only serious danger of pollution of the waters of this source at the present time is that which might be caused by this use of the pond and its shores.

In the opinion of the Board, there are no conditions existing about Chapin or Five Mile ponds, or within the water-shed of either pond, which would render the water of these sources unsafe for drinking if existing laws and regulations are enforced.

Aug. 8, 1904.

To the Board of Water Commissioners of the City of Springfield.

Gentlemen: — Your communication of June 1, 1904, requesting the advice of the State Board of Health as to a proposed experiment at the Ludlow reservoir for the removal of the organisms which render that source objectionable, to be made under the direction of this Board, in co-operation with Dr. George T. Moore of the United States Department of Agriculture, has been considered by the Board.

At the time your request was received *Anabœna* had not yet appeared in considerable numbers either in Ludlow reservoir or in any source available for experiment. About the middle of July the organism began to appear in large numbers in the Belchertown reservoir, formerly a part of your system of water supply, but not now used; and arrangements were then made with Dr. Moore to make an experiment as to the effect of treating this reservoir with copper sulphate for the removal of the *Anabœna*, and a solution of copper was applied to the reservoir under the direction of Dr. Moore July 21. Many samples of the water were collected for analysis from the reservoir before treatment, and again twenty-four hours after the treatment, and other samples have been collected since that time. The numbers of *Anabœna* present in the water decreased materially within twenty-four hours after the copper sulphate was applied, and the organism subsequently disappeared from the reservoir; but the quantity of copper remaining in the water twenty-four hours after the treatment was found to be nearly equivalent to the quantity applied.

The Board regards it as essential to determine what becomes of the copper before applying it to a reservoir used, or liable to be used, as a source of drinking-water supply; and the Board cannot advise the application of this substance to the water of the Ludlow reservoir until its probable effect is more definitely known. Abandoned reservoirs are available and are being used by the Board for further investigation, and other necessary experiments are being made; but from present appearances safe conclusions can hardly be reached for use during the present season.

SPRINGFIELD (SPRINGS).

JULY 7, 1904.

To the Board of Health of the City of Springfield, H. C. EMERSON, M.D., *Clerk*.

GENTLEMEN: — In response to your request for advice as to the safety for drinking purposes of the water of the Hygeia Spring, the Massasoit Spring, the Iroquois Spring and the Wilbraham Mountain Spring, from which it is proposed to distribute water for drinking in the city of Springfield, the Board has caused the springs to be examined and samples of their waters to be analyzed.

No change appears to have taken place in the conditions about the Hygeia Spring, and the results of an analysis of a sample of water show that its condition remains about the same as at the time of the previous examination last year. The water entering this source has at some time been considerably polluted and subsequently well purified in its passage through the ground, and in its present condition is probably safe for drinking.

The water of the Massasoit Spring is also found to be of about the same quality as at the time the previous examination was made. The conditions about this spring remain the same as at the time of the previous examination, and this source continues to be exposed to danger of pollution by visitors, as in former years.

The water of the Iroquois Spring shows, upon analysis, an improvement in many respects over its condition at previous times, and the conditions about the spring have also been materially improved by the construction of a building to prevent access to the spring by visitors.

The water of the Wilbraham Mountain Spring has slightly improved since the previous analysis was made, but the conditions about the spring remain the same as at the time of the previous examination. It is desirable that the present method of collecting water from the spring be changed, and that the spring be covered and all water drawn by means of a pump or pipe, so arranged that the waste water or water polluted in handling may not flow back into the spring.

The Board would call attention to the fact that spring waters are in many cases contaminated in the process of collection and delivery to consumers, and that it is important that danger of contamination from these causes should be guarded against.

STOCKBRIDGE.

MARCH 3, 1904.

TO ARTHUR LAWRENCE, D.D., and others, *Stockbridge, Mass.*

GENTLEMEN: — In response to your request for an examination by this Board of the condition of the water supply of the town of Stockbridge, and information as to methods by which the quality of the water can be improved, the Board has caused Lake Averic, the source of supply, to be examined by one of its engineers, and has examined the results of many analyses of this water made within the past few years.

The water-shed of Lake Averic is uninhabited, and the source is free from danger of sewage pollution. The water has generally but little color, and the quantity of organic matter present in the water, as shown by the analyses, is not excessive for a surface water. The results of the examinations show that the water supplied to the town is frequently affected by the presence of *Uroglena* and other organisms of kinds which impart to water an offensive taste and odor, rendering it objectionable for drinking and other uses, and it is probable that the objectionable quality of the water supplied to Stockbridge is due chiefly to the presence of such organisms.

The microscopic organisms and the disagreeable tastes and odors could be removed from this water by filtration through sand, at no great difficulty or expense; and this is the best practicable plan, in the opinion of the Board, of improving the quality of the water supply of the town of Stockbridge. The head available between the pond and the pumping station is ample to allow for filtration of the water; and if sand filters 5 feet in depth, having an area of about one-tenth of an acre, should be constructed in this neighborhood, all of the water supplied to the town could be filtered and rendered satisfactory at all times, and the Board would advise the adoption of this method for the purification of the water supply of Stockbridge. The filters should be designed and constructed under the direction of an engineer of experience in the construction of such works.

UXBRIDGE.

JULY 7, 1904.

To the Water Committee of the Town of Uxbridge.

GENTLEMEN: — The State Board of Health received from you on May 24 an application for advice with reference to an additional water supply for the town of Uxbridge, in which your proposed plan is described as follows: —

> The town of Uxbridge proposes to increase its water supply by the addition of ground water from the valleys of Crony and Cold Spring brooks and well on Douglas Street, — all of the above, or either of them.

Subsequently tests were made in the valley of Crony and Cold Spring brooks and in the valley of Williams Hill Brook, a tributary of Cold Spring Brook, to determine the practicability of obtaining a ground-water supply in either of these valleys. Samples of water from the test wells were collected and sent in by you while the tests were in progress.

The Board has caused these samples of water to be analyzed and an examination of the localities indicated by you to be made by one of its engineers, and has considered the available information as to the proposed sources of supply.

The samples of water sent in by you are of little value in determining the probable quality of the water obtainable in the regions indicated, on account of the large quantity of sand and dirt collected with the samples. The results of the tests as a whole show, however, that it is improbable that any considerable quantity of water can be obtained from the ground in the valley of Crony Brook or in the valley of Williams Hill Brook; and, while the tests in the valley of Cold Spring Brook indicated that the conditions existing there are less unfavorable than in the other places, it is very doubtful whether it is practicable to obtain in this valley enough water for the supply of Uxbridge at reasonable expense.

Examinations made by the Board show that there are places in Uxbridge in which the conditions are much more favorable, judging from surface indications, for obtaining water freely from the ground, than in the localities in which your tests have been made. Under the circumstances, the Board does not approve the sources of water supply proposed in your application.

An adequate public water supply is greatly needed by the town, and the Board would urge that investigations be made without delay in those places where the conditions appear favorable for obtaining an adequate water supply.

Oct. 6, 1904.

To the Water Committee of the Town of Uxbridge, Mr. James Daley, *Chairman.*

Gentlemen: — The State Board of Health, in accordance with your application of Sept. 16, 1904, for advice as to taking water for the supply of Uxbridge from the ground near the West River, a short distance above the mouth of Meadow Brook, has caused the locality to be examined by one of its engineers and a sample of water collected from a test well driven in this locality to be analyzed.

The water was found upon analysis to be of excellent quality for the purposes of a public water supply. It is impracticable to determine, however, from a test like this, whether the quality of the water would remain satisfactory if water should be drawn from the ground in such quantity as would be necessary for the supply of Uxbridge.

Regarding the quantity of water that can be obtained from the ground at this place, it is not practicable to form a definite opinion from the information now available. The soil in this neighborhood appears to be coarse and porous to a considerable depth, and the test well yielded water freely when pumping with a hand pump, — indications which are favorable for obtaining water from the ground in considerable quantity.

The Board would advise, as the next step in your investigation, that you proceed to make further tests to determine the probable quantity and quality of water to be obtained from the ground at this place, by sinking several wells, connecting them together and pumping from them with a steam pump for a period of at least a week, and at a rate as great as will be necessary for the supply of Uxbridge. It is essential that a further test be made before it will be practicable to determine whether the source is an appropriate one for the water supply of Uxbridge. The Board will assist you in making the test, if you so request, by making the necessary analyses of water from the wells. The present is a favorable season for such tests, and it is desirable that the test be begun without unnecessary delay.

Jan. 5, 1905.

To the Water Supply Committee of the Town of Uxbridge, Mr. Arthur R. Taft, *Clerk.*

Gentlemen: — The State Board of Health has considered your communications of December 15 and 29, for advice relative to taking a water supply for the town of Uxbridge from the ground in the valley of Mendon Pond Brook, near its confluence with the West River, and has examined the results of your recent investigations in this locality and the analyses of samples of water collected daily between December 6 and December 15, during a pumping test, from a group of tubular wells located near the northerly bank of Mendon Pond Brook, and about 500 feet from the West River.

The pumping test was made in a dry period, but a quantity of water ample for the present requirements of Uxbridge was obtained from the temporary works without difficulty and without material lowering of the ground water, indicating that a sufficient quantity of water for the town can be obtained from the ground in this region.

The results of the analyses of water collected during the test show that it was at all times clear, colorless and odorless, and otherwise of good quality for the purposes of a public water supply. The region about the wells is very sparsely populated, and if the town should secure control of a considerable area of land about the wells, and prevent its cultivation and the building of dwelling houses there, the quality of the water can be protected, and this source will, in the opinion of the Board, be a satisfactory one for the town of Uxbridge.

Ground waters, such as the water of these wells, deteriorate rapidly when exposed to light; and it is important, if this source of supply shall be used, that the water be stored in a covered reservoir and kept from exposure to light.

Wakefield.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on Oct. 6, 1904, for preventing the pollution and securing the sanitary protection of the waters of Crystal Lake and its tributaries, used by the town of Wakefield as a source of water supply.

Waltham.

March 3, 1904.

To Hon. Murray D. Clement, *Mayor, Waltham, Mass.*

Dear Sir: — The State Board of Health has considered the application of the mayor of Waltham, received in the latter part of last year, for advice as to the future water supply of the city, as stated in the following communication: —

> The city of Waltham has now under consideration plans for a covered reservoir for maintaining the quality of the water, also plans for increasing the supply, as outlined in the last report of the water department. Some metering has been done.
>
> The advice of the State Board is asked as to whether the supply can be maintained in its present purity and in satisfactory quantity for a period of time sufficient to justify this large expenditure on our works, in view of the probable cost to the city of entering the sytem and taking water from the metropolitan works.

In response to this application, the Board has considered the results of analyses and other information now available as to the present condition of your water supply, and has considered the plans for increasing the supply as outlined in the report of the water department, and other possible plans for enlarging the water supply of the city.

The water of the present filter-gallery, after being covered some twelve years ago, so as to exclude the light, was for several years generally clear, odorless and nearly colorless, and changed very little in character from month to month. In more recent years its quality has deteriorated; and in a communication to the water works authorities of the city, dated July 3, 1902, the Board advised as follows as to possible remedies: —

> The results of analyses of water from the well have shown for several years that the water passing through the ground into the well is being polluted; and there has been a deterioration in the quality of the water drawn from the well, owing to an increase in the quantity of iron, though the quantity of iron present in the water has not yet become so great as to noticeably affect its quality. The increase in the quantity of iron is doubtless due to the passage of imperfectly filtered water into the well from Charles River, and in part to pollution of the ground waters tributary to the well.
>
> In a communication to the mayor of Waltham in 1897 the Board suggested, as possible remedies for the deterioration in the water, that all sewage be removed from the territory supplying water to the filter basin; that the draft from the basin be diminished so that it should not exceed the amount drawn from the basin before the quantity of iron began to increase; and that another source be secured for the additional water required for the city.
>
> It does not appear that sewers have yet been extended into the territory near the wells which required sewerage at that time, though plans for the sewerage of this territory have now been prepared. The quantity of water used by the city in 1901, moreover, was 50 per cent. greater than in 1897, and more than twice as great as at the time the quantity of iron in the water began to increase. Under the circumstances, it is likely that the quality of the water will continue to deteriorate.

If the quality of the water should continue to deteriorate and the quantity of iron increase at as great a rate as in the past few years, the water would soon become objectionable for many domestic purposes, and a supply of water from some other source become necessary.

The offensive taste and odor of this water, frequently complained of in past years, has been due, since the covering of the filter-gallery, to the presence of microscopic organisms in the water of the open distributing reservoir, and it has been known for many years that trouble from this cause could be prevented by covering the reservoir; but a covered reservoir would have no effect in preventing consequences of deterioration due to the presence of an excessive quantity of iron in the water, and such a reservoir would be of no material value if a water supply should be introduced hereafter from surface sources, such as those used by the metropolitan district referred to in the application. It is essential to decide, if possible, as to the source from which the future supply is to be obtained, before making changes at the reservoir.

As to possible sources of supply, reference is made in the application to the metropolitan water district and to the plan of obtaining a supply from the ground near the river above your present works.

If a supply of good water, ample, in connection with the present source, for the requirements of the city for a considerable period of years, could be obtained from the ground near the river above the present filter-gallery, and if the quality of the water of the latter source should materially improve, as a result of a greatly decreased draft from this source, it would then be practicable for the city, by building a covered reservoir, to secure a supply of good water, free from the objectionable conditions now complained of, and at less expense than by joining the metropolitan district.

The examinations made with reference to securing an additional water supply, as described in the annual report of the water board, referred to in the application, consisted in sinking several test wells in the neighborhood of the river, from 600 to 1,400 feet up stream from the present filter-gallery, the tests indicating that the soil in this neighborhood was coarse and porous to a considerable depth. Observations upon the height of the water in these wells, however, showed that in all cases the water was lower than the level of the water of the river, indicating clearly that the ground water at the places at which these wells are located is already influenced by the pumping from the present filter-gallery.

In order to secure a very large additional supply from the ground near the Charles River, and at the same time reduce the rate of filtration through the ground in the area affected by pumping from your present filter-gallery, it will be necessary to locate the new wells or other sources of additional supply beyond the area materially affected by pumping from the present source.

The soil near the river above the present filter-gallery consists apparently of coarse and porous gravel for a long distance up stream; and it seems probable that wells could be located at some point in this region beyond the area influenced by pumping from your present filter-gallery, from which water can be drawn in large quantities.

The region about the river above your present filter-gallery within the limits of the city and on the opposite side of the river in Newton is, however, becoming somewhat thickly populated, and the river is also considerably polluted at points above Waltham. The stream and its banks are now used also as a pleasure resort by large numbers of people, and it may be impracticable to secure ground water of good quality in this region. If this should be found to be the case, there are two other possible methods by which a supply of water might be obtained: one by drawing water from Stony Brook (the right to a supply from this source having been reserved to the city of Waltham in the legislation of 1884); and the other by filtering the water of the Charles River.

The water of the Charles River, from the stand-point of its use as a source of public water supply, is considerably polluted, as already indicated, and its waters would be unsafe for drinking unless thoroughly purified by filtration. By proper filtration the water could undoubtedly be made safe for drinking; but it is not desirable, in the opinion of the Board, to resort to this plan of securing a water supply, if it is practicable to secure a supply from sources which are protected from sewage pollution.

Stony Brook would furnish an ample supply of water for the city of Waltham for a long time in the future; and, inasmuch as the city has a right to a supply from this source, it is important to consider the possible advantages of using it, as compared with other available sources. In the consideration of this source, it is necessary to take into account the probability of a considerable increase in the population on the water-shed, and the possible necessity of filtering the water at some future time. The Board is unable to advise you as to the probable cost of a supply from this source, but it seems likely that the cost will be less than the cost of taking a supply from the metropolitan district.

Considering all the circumstances, the Board would advise the city of Waltham to make investigations as to the practicability of obtaining an auxiliary supply of water from the ground in the neighborhood of Charles River, beyond the area influenced by pumping from the present filter-gallery; and, if it is found practicable to obtain a satisfactory auxiliary supply in this way, that an estimate be made of the probable cost of works for supplying the city by this plan, including the cost of a covered reservoir.

Tests of the ground in the neighborhood of Charles River should be made in a thorough manner, and should include an adequate pumping test, to determine the probable quantity and quality of water obtainable. At the same time, information should be collected as to the probable cost of a supply both from Stony Brook and from the metropolitan water district, having in view the present needs of the city and its probable future requirements for several years. The Board will assist you in these investigations, if you desire, by making the necessary analyses of water, and will give you further advice in the matter when the results of further investigations are available.

WALTHAM (ALDEN CLARK).

OCT. 6, 1904.

To MR. ALDEN CLARK, *Waltham, Mass.*

DEAR SIR: — In accordance with your request of August 24 for an examination of a spring located in the valley of Beaver Brook, near the corner of Bacon and Lexington streets in Waltham, from which you state that you propose to sell water for drinking, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

The water-shed of the spring is uninhabited, and the results of the analysis of the water show that it is of good quality for drinking.

Under present conditions, this spring may, in the opinion of the Board, be used with safety as a source of drinking water supply, provided suitable precautions are used to prevent the entrance of surface water or the pollution of the water of the spring in collecting and distributing it to consumers.

WELLESLEY (WELLESLEY COLLEGE).

JULY 11, 1904.

To MISS CAROLINE HAZARD, *President, Wellesley College, Wellesley, Mass.*

DEAR MADAM: — The State Board of Health has considered your request for advice as to the quality of the water of certain tubular wells recently driven on the grounds of the college in Wellesley, and has caused the wells and their surroundings to be examined and samples of their waters to be analyzed.

The results of the examination show that the water of these wells is at the present time of good quality for drinking. An analysis of a sample of the water of the wells put in in the latter part of last year shows that the quality of this water has deteriorated slightly, as compared with the analyses made in October of last year.

Both groups of wells are located within a short distance of the area formerly used for sewage disposal, and sewage has been discharged into the ground at other places in the neighborhood. With these conditions the water of both groups of tubular wells is liable to deteriorate and become unsafe for drinking, if a large quantity of water, such as would be required for the supply of the college, should be drawn from them continuously.

It appears that water from one of these groups of wells is now used for mechanical and certain other purposes in the college buildings; and the Board would recommend that, before using this water for drinking, tests be made from time to time, to determine what changes, if any, take place in its quality while it is being used as at present; and the Board will, upon request, make the necessary analyses, if you will have the samples collected.

If it is not deemed desirable to continue the use of water from these wells for any purpose until its probable quality is known more definitely, the Board would recommend that a pumping test be made by pumping from the wells continuously for a period of two weeks at a rate as great or greater than that at which the water would be drawn if the wells were used as a source of water supply for the college; and that samples be collected during the test, to observe what changes, if any, take place in the quality of the water. The Board will, in this case also, upon application, make the necessary analyses of the water, and in either case will give you further advice as to the quality of the water of these wells when the results of further tests are available.

OCT. 6, 1904.

To MISS CAROLINE HAZARD, *President, Wellesley College, Wellesley, Mass.*

DEAR MADAM: — Your communication of September 28, requesting further advice as to taking water from a system of tubular wells on the college grounds for the supply of the college, has been received and considered by the State Board of Health.

It appears that, since the communication of the Board made in July last, recommending a further test of the practicability of obtaining a good water from wells near the power house in the northerly part of the college grounds, you have caused additional wells to be put in there, and a pumping test to be made by pumping from eight wells for a period of about ten days, from August 12 to 22, at a rate of about 350,000 gallons per day; and samples of the water of the wells, collected and sent in by you from time to time during the test, have been analyzed by direction of the Board.

The wells are located in a region having porous soil over a large area, which extends to a depth of nearly 70 feet at the wells. These conditions, taken in connection with the large quantity of water pumped from the wells during the test, indicate that a sufficient supply for the college could probably be obtained from the ground at this place.

The results of the analyses of the samples of water show that it remained practically constant in quality throughout the test, being clear, colorless and free from odor, and in other respects of good quality for water supply purposes.

The quality of the water showed no tendency to deteriorate during the pumping test, but there are possible sources of pollution which may in time affect the quality of the water; and it is important, in the opinion of the Board, that, if water from these wells be used for the supply of the college, it be analyzed from time to time, in order that any deterioration may be detected. The Board will make the necessary analyses, if you will have the samples collected and sent to its laboratory.

Westford.

Feb. 4, 1904.

To the Board of Selectmen of the Town of Westford.

Gentlemen: — The State Board of Health has considered your application for advice with reference to a proposed water supply for the town of Westford, to be taken from the ground in the neighborhood of the Westford station on the Nashua, Acton & Boston Railroad, so called, and has caused the locality in which it is proposed to obtain the supply to be examined by its engineer.

The conditions in the neighborhood of the station, and especially north of the highway leading from Forge Village to Westford west of the railroad, appear to be favorable, judging from surface indications, for obtaining good water freely from the ground by means of wells, and the locality is favorably situated for supplying water to the three main villages in Westford without special difficulty.

The Board would advise, as the next step in the investigation, that you cause tests of the ground in this region to be made, by means of wells, to determine the character of the soil and the probable quantity of water to be obtained, and that you cause samples of the water from test wells to be analyzed to determine its quality. These tests should be made under the direction of an engineer of experience in matters relating to water supply, and the Board will assist by making the necessary analyses of samples of water, and will give you further advice in the matter when the results of the tests are available.

The Board has also, in accordance with your request, examined a considerable number of private wells in Westford and Graniteville, and caused samples of their waters to be analyzed. Nearly all of these wells show evidence of serious pollution by sewage, and in many cases it is not practicable for those dependent upon them to secure water of better quality upon their own premises.

A public water supply, aside from its other advantages, is greatly needed in these villages to make it practicable to discontinue the use of polluted waters for domestic purposes.

WESTON (CEMETERY NEAR SOURCE OF WATER SUPPLY OF CAMBRIDGE).

APRIL 28, 1904.

To the Board of Selectmen of the Town of Weston, MR. FRANCIS BLAKE, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application of March 31, for the approval of the use for cemetery purposes of certain land in Weston lying south of and adjacent to Linwood Cemetery, shown upon a plan submitted with your application, and has examined this land. With the exception of a low area at the south-easterly corner, the land is dry, and unlikely, in the opinion of the Board, to cause pollution of adjacent waters if used for the purpose indicated.

The Board hereby approves the use for cemetery purposes of the land south of Linwood Cemetery, marked "Proposed Addition, 8.91 Acres," as shown upon a plan entitled "Linwood Cemetery, Weston, Surveyed by John N. McClintock, C.E. Scale, 1″ = 200′," and filed in the office of this Board April 6, 1904, provided that no interment shall be made in any portion of the area within 200 feet of the south-easterly corner thereof, as shown on the above-described plan.

WEST SPRINGFIELD.

JAN. 5, 1905.

To the Board of Water Commissioners of the Town of West Springfield, MR. C. M. WOODWARD, *Secretary.*

GENTLEMEN: — The State Board of Health received from you on September 26 the following communication: —

> The town of West Springfield, being for several years in need of an additional water supply, and having investigated the several possible schemes for obtaining such supply, has settled upon the source known as the Bear Hole Brook, and the

water-shed contributory thereto, lying within the limits of said town, except a small portion in the adjoining city of Holyoke. Options have been obtained on a large part of the land needed for full future development, engineering features worked out, funds voted by the town for the work at present contemplated, and preparations are well along for carrying it out. We would ask of your Board advice in the matter of development of the supply, and putting it into thoroughly good shape for the town's use. We desire to know the proper means of securing the purity of the water, the extent of ground necessary to control to prevent contamination, our rights as against public carelessness leading to contamination, and to receive such general information as you can give us bearing on the work. We would propose to develop the system slowly, as the needs of the town require, but to do the work in hand thoroughly and systematically.

The plan for developing a water supply from Bear Hole Brook, prepared by your engineers in 1899, provided for the construction of a storage reservoir holding about 311,000,000 gallons upon this stream, by constructing a dam about a mile below Bear Hole Spring, so called.

The plan which you now propose to adopt, and which you have described further to the engineer of the Board, provides for the construction at the present time of a pumping station near the brook, in the neighborhood of the proposed dam, and for a pipe line through which the water is to be forced to a new stand-pipe, which you are now preparing to construct upon a hill about one and one-half miles north-west of the village.

The Board has caused a further examination of the locality to be made by one of its engineers, and has considered the results of investigations relative to obtaining a water supply for the town.

Bear Hole Brook forms the outlet to Ashley Pond, one of the sources of water supply of the city of Holyoke; and when the pond is full, or nearly so, a large quantity of water leaks from the pond into the brook below the dam. The soil of part of the drainage area of the brook above the proposed point of taking is coarse and porous, especially on the easterly side, so that the flow is maintained in dry weather. Under ordinary conditions it is probable, in the opinion of the Board, that a sufficient additional water supply for the present needs of West Springfield could be obtained from this source without storage, but in a very dry season the yield of the stream might prove inadequate for the requirements of the town.

The water-shed of Bear Hole Brook is sparsely populated, but there is a picnic ground a short distance above the proposed point of taking, and there are dwelling houses and other buildings on the stream farther up the valley. In order to protect adequately the purity of the water of the stream, it would be necessary to purchase and remove many of the dwelling houses and buildings now within the water-shed, the cost of which, judging from the information furnished by you, would be large; and it would also be necessary, in order to secure protection in the future, to control a considerable area of land within the water-shed.

Considering the circumstances, the Board does not deem it advisable for West Springfield to take water directly from Bear Hole Brook, as now proposed. It appears to be possible to obtain a considerable quantity of water from the water-shed of Bear Hole Brook by means of wells or filter-galleries sunk in the valley of the brook, at places where land could be secured at reasonable cost, and thus avoid the large expense for lands, buildings, etc., which would be necessary under the plan now proposed; but no tests have been made in the valley which would show whether such a plan for securing a water supply for West Springfield would be practicable, or not. The town is growing rapidly, and, while a quantity of ground water might be obtained in this valley by means of wells or filter-galleries, which would be sufficient for present requirements if used in connection with existing works, it will be necessary, if the growth of the town continues, to secure a further supply. The plans for developing a large supply from Bear Hole Brook, proposed by the engineers who investigated the question of a water supply for West Springfield five years ago, provided for the construction of a storage reservoir upon this stream, holding a little over 300,000,000 gallons; and there is no doubt that with such a reservoir an ample supply of water for the requirements of West Springfield could be made available. The reservoir, however, would be supplied in part with ground water, which would be liable to deteriorate greatly in the storage reservoir, and become objectionable on account of organic growths and the offensive tastes and odors which they produce.

The Board has advised you on previous occasions, when considering the future water supply of West Springfield, to examine the practicability of obtaining a ground-water supply from the neighborhood of Pond Brook, near the Holyoke and Westfield Railroad, but it does not appear that any studies of this locality have been made. The Board would again advise that the question of water supply from the valley of Pond Brook be given careful consideration, before the town proceeds to develop a supply from the valley of Bear Hole Brook; since it seems likely, from the investigations that have been made by the Board, that an adequate supply of excellent water can be obtained from the valley of Pond Brook at no greater, and very likely at less, expense than from Bear Hole Brook, and that a water of much better quality could be secured.

Investigations might at the same time be made of the practicability of obtaining a ground-water supply in the valley of Bear Hole Brook sufficient for the present requirements of the town; and if it should be found practicable to obtain a considerable supply of good water from the ground in this valley, there might be economy in the use of this source for a time, rather than to go to Pond Brook in the beginning.

In case you decide to make further investigations in the valley of Pond Brook or in the valley of Bear Hole Brook, with a view to obtaining a ground-water supply, the Board will, upon request, make the necessary analyses of water, and will give you further advice when the results of further investigations are available.

WOBURN (W. W. CUMMINGS).

NOV. 3, 1904.

To MR. W. W. CUMMINGS, *Boston, Mass.*

DEAR SIR: — In response to your request for advice as to the quality of the water of certain springs at Woburn, from which you propose to sell water for drinking purposes, the Board has caused the springs and their surroundings to be examined and samples of their waters to be analyzed.

The results of the analysis of the water of the spring near 15 Winter Street show that the water is probably safe for drinking at the present time; but the spring is located beside a brook, the water of which is exposed to pollution from buildings on its water-shed, and at times of high water the brook water can evidently find its way into the spring, and, in the opinion of the Board, this spring is not, under the circumstances, a safe source of drinking water.

The water of the spring farther north, near the old mill pond near Winter Street, contained, when examined, a much greater quantity of organic matter and a larger number of bacteria than are found in good spring waters. These conditions may possibly have been due in part at least to the fact that the spring is uncovered, and that surface water can enter it. The spring cannot in its present condition be regarded as a safe source from which to take water for drinking. It is possible that the water of this spring might safely be used for drinking if the spring were cleaned and covered so as to exclude surface water.

WORCESTER.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on April 7, 1904, for preventing the pollution and securing the sanitary protection of the sources of water supply of the city of Worcester.

WRENTHAM.

APRIL 7, 1904.

To the Committee on Water Supply of the Town of Wrentham, MR. WILLIAM F. MAINTIEN, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application received March 8, 1904, for advice with reference to a proposed water supply for the town of Wrentham, and the plans and report submitted therewith, which provide for taking water either from tubular wells and springs near the Trout Ponds, or from tubular or other wells near Archer's

Pond, and has caused the localities to be examined and two samples of water collected from tubular wells at these places and sent in by you to be analyzed.

The results of the analyses show that the water of the test wells at both places is of good quality for the purposes of a public water supply, the water of the tubular well near the Trout Ponds being a little the better of the two.

It does not appear that there is likely to be a very material difference in the cost of a supply from either the Trout Ponds or Archer's Pond sources, but a supply from the former source seems likely, from the estimates presented, to cost a little less than a supply from the latter source.

The superficial area of the water-shed of the Trout Ponds, as shown upon a plan submitted with your application, is stated to be 45.4 acres, but additional areas are indicated that may be tributary to this source. Measurements of the flow of water from the lower pond of the group, made last July, show that the flow from these ponds at that time amounted to about 150,000 gallons per day. In a very dry season it is probable that the flow would be less than this amount; and these circumstances indicate that it is somewhat doubtful whether a sufficient quantity of water for the supply of Wrentham, after water has come into general use in the town, can be obtained from wells in this neighborhood.

The results of the tests and investigations thus far made are, on the whole, favorable to obtaining an ample supply of water for Wrentham from the region near Archer's Pond; but before taking a supply from either source it is necessary, in the opinion of the Board, to make further tests, to determine more definitely the probable quantity and quality of water that the sources are likely to yield.

Since water of somewhat better quality can apparently be obtained in the neighborhood of the Trout Ponds, and probably at a somewhat smaller cost than from the neighborhood of Archer's Pond, the Board would advise that tests be made first of the soil about the Trout Ponds by means of tubular wells, and that tests should also be made in the valley of the stream below the lower pond. If these tests show that porous soil extends to a considerable depth and that water can be obtained freely from the ground by means of wells, a pumping test should be made, and the effect of the pumping upon the level of the ground water and the flow of the water of the ponds carefully noted. When the results of suitable tests and observations are available, it will be practicable to determine whether this source is likely to yield a sufficient quantity of water for the supply of the town. The cost of such a test would be inconsiderable, as compared with the cost of changing the source after the works have approached completion or subsequently, as would be necessary if it should be found that the supply was inadequate.

If, as a result of further tests at the Trout Ponds, that source should not be deemed appropriate for the use of Wrentham, further tests should then be made in the neighborhood of Archer's Pond.

The Board will assist you in such investigations of the proposed sources as you may decide to make, by making the necessary analyses of water, and will give you further advice when the results of further tests are available.

Ice Supplies.

The following is the substance of the action of the Board during 1904 in reply to applications for advice relative to sources of ice supply: —

Chicopee.

Jan. 5, 1905.

To the Board of Health of the City of Chicopee.

Gentlemen: — In response to your request for advice as to the use, as a source of ice supply, of a reservoir to be constructed upon the stream which crosses the Rockrimmon Road, about 300 feet north of Plainfield Street, in the extreme southerly part of Chicopee known as Glenwood, the Board has caused the locality to be examined and a sample of the water of the stream to be analyzed.

The results of the examination show that there is a large cemetery within the water-shed of the stream, and there is also apparently a considerable number of dwelling houses within this water-shed near its upper end. An analysis of a sample of the water shows that the stream receives considerable pollution at the present time, and is not a desirable source of ice supply.

It is possible that ice which might safely be used for domestic purposes could be obtained from a reservoir on this stream by removing from the ice, when harvesting, the first inch which formed upon the pond and all ice formed above this first inch, including snow ice and ice formed by flooding, and by rejecting all ice containing particles of foreign matter.

It is important, in constructing a reservoir for use as a source of ice supply upon this stream, that the reservoir be made of sufficient size so that there will not be a rapid current of water through the pond.

Everett.

Aug. 4, 1904.

To the Board of Health of the City of Everett.

Gentlemen: — The State Board of Health received from you on July 16, 1904, a request for an examination of the following sources, from which ice is taken for sale in Everett: Pentucket Lake, in Georgetown; Crystal Lake, in Wakefield; Bennett's Pond, in Melrose; Crystal Lake, in Melrose; Towner's Pond, in Melrose; Long Pond, in Melrose and Saugus; Swain's Pond, in Melrose.

Subsequently the request for advice as to the use of Crystal Lake, in Wakefield, as a source of ice supply, was withdrawn.

The Board has caused the various lakes and ponds mentioned in your application to be examined, and samples of their waters, and of the ice harvested from them in all cases where samples were obtainable, to be analyzed.

With the exception of Pentucket Lake, in Georgetown, all of the sources mentioned in your application were examined by the Board in 1901, in response to a request from the city of Melrose for advice as to the use of these lakes and ponds as sources of ice supply; and the Board advised the authorities of that city as follows concerning the use of ice from Crystal Lake, in Melrose (otherwise known as Ell Pond), Bennett's, Long, Swain's and Towner's ponds, the latter being known at that time as Dorr's Pond: —

> In response to your request for advice as to the quality of the ice of Ell Pond, Bennett's Pond, Long Pond, Stillman's Pond and Swain's Pond, in Melrose, the Board has caused the various sources of ice supply in Melrose which have been brought to its attention to be examined, and samples of the water and ice to be analyzed.
>
> Ell Pond is situated in the central portion of Melrose, and receives the drainage from a territory containing a dense population, and is evidently considerably polluted by sewage.
>
> Numerous samples of ice collected from various parts of this pond, both during the winter just passed and the previous winter, have been analyzed by the Board; and, judging from the results of all its examinations, the Board is of the opinion that the ice of Ell Pond, as formed, cannot be safely used for domestic purposes, although the bottom portion of the ice, when it is clear and contains no particles of foreign matter, might safely be so used.
>
> Under the existing conditions, the only safety in using such ice lies in a proper inspection, under your direction and control, to insure the removal from the ice, when it is harvested, of the first inch that forms upon the pond, and all of the ice which forms above the first inch, whether by snow or rain or flooding, and to insure the rejection of all ice containing particles of foreign matter.
>
> The Board would advise that no ice be cut in the immediate neighborhood of the feeders of the pond, the flow from which may cause matters to become entangled in the ice, or at any place in the pond where the water is shallow, and there would be danger that weeds or organic matters from the bottom of the pond might be taken up by the ice.
>
> All of the other sources examined show evidences of sewage pollution, and the Board is of the opinion that the only safety in using ice from these sources also, excepting Dorr's Pond, is to provide that the harvesting of the ice shall be done under your direction and control, and that the ice be inspected in the same manner as recommended in the case of Ell Pond: that is, to insure the removal from the ice, when it is harvested, of the first inch that forms upon the pond, and all of the ice which forms above the first inch, and to insure the rejection of all ice containing particles of foreign matter.
>
> Some of these ponds are quite shallow, or contain large areas where the depth of the water is small. The Board would call special attention to the liability, in

shallow ponds and in all ponds if ice is cut near the shore, that weeds, grass or other foreign matter may be frozen into the ice, which would render it entirely unfit for domestic uses. This was the case with the ice examined from Dorr's Pond, and the Board would advise that the ice from this source be not used where it will come in contact with food or drinking water.

The recent examination of these sources shows that no material change has taken place in the condition of the various ponds or their surroundings; and, in the opinion of the Board, ice taken from these sources can be used with safety only by observing carefully the precautions advised in the communication quoted above. The sample of ice collected recently from Towner's Pond, formerly known as Dorr's Pond, did not differ materially in quality from the others.

Ice collected from Pentucket Lake, in Georgetown, may, in the opinion of the Board, be used with safety for domestic purposes.

FALMOUTH.

JULY 7, 1904.

To the Board of Health of the Town of Falmouth, Mr. RUSSELL S. NYE, *Secretary*.

GENTLEMEN: — In accordance with your request of June 15, the State Board of Health has caused an examination to be made of Shivericks Pond and its surroundings, and has caused samples of the water of the pond and of the ice found in the ice house located at the westerly end of the pond to be analyzed.

The pond is located near the village, and an analysis of the water indicates that it contains considerable organic matter, but there is no evidence that this is derived from sewage pollution. A sample of the ice collected from one of the ice houses was found to consist of about 10 inches of clear ice, with a thin layer of snow ice on top. The clear ice was free from foreign matter, and was found, upon analysis, to be of good quality.

In the opinion of the Board, this ice may safely be used for domestic purposes, but the snow ice is liable to contain impurities, and should be rejected.

HARDWICK (WHEELWRIGHT).

SEPT. 1, 1904.

To the Board of Health of the Town of Hardwick, Mr. CHARLES F. ANGELL, *Agent*.

GENTLEMEN: — Your communication of August 5, enclosing a letter of the Winimissett Ice Company of Hardwick, relative to the pollution of the Ware River above the village of Wheelwright, has been considered by the State Board of Health.

It appears that the water of the river is used as a source of water supply by the George W. Wheelwright Paper Company, but the letter from that corporation to your board states that the paper company has advised the persons who take water from its pipes not to use any of it unless it has been boiled. The stream receives much pollution from mills and villages above Hardwick, and is not a suitable source of drinking water supply, and should not be so used.

A sample of ice said to have been harvested from the river last winter was found to contain but little organic matter, and was in other respects of good quality, indicating that at the time this ice was harvested it was possible to obtain from this source ice which might safely be used for domestic purposes.

While the conditions remain as at the time this ice was formed, it is possible to obtain from this source ice which may safely be used for domestic purposes; but ice from such a source can only be used with safety by removing the first inch which forms upon the pond, and all ice formed above this first inch, whether by snow or rain or flooding, and rejecting all ice containing particles of foreign matter.

The State Board of Health, under the provisions of section 118 of chapter 75 of the Revised Laws, is authorized, under certain circumstances, to take action for the prevention of the pollution of an ice supply; but. in the opinion of the Board, it would be impracticable to prevent the pollution of this stream under that law, unless at great expense to the ice company.

HOLYOKE.

AUG. 4, 1904.

To the Board of Health of the City of Holyoke.

GENTLEMEN: — In response to your application for an examination of two ice ponds in Holyoke, and advice as to their use as sources of ice supply for domestic purposes, the Board has caused the ponds and their surroundings to be examined and samples of the water and ice to be analyzed.

One of the ponds, known as Bray's Pond, is located south of Westfield Road and west of Northampton Street in Holyoke. The water of this source was found to contain a very large quantity of organic matter, but the quantity of organic matter found in a sample of the ice was small. In response to a previous application for advice as to the use of this pond as a source of ice supply, the Board advised you as follows: —

> Bray's Pond, located south of the Westfield Road and west of Northampton Street, evidently receives considerable polluting drainage, and the effect of this pollution is evident in the analysis of a sample of the water. The ice cut from this pond was found to contain a larger amount of organic matter than is usually present in ice from unpolluted sources, and this pond in its present state cannot be considered a safe source from which to take ice for use in connection with food or drinking water. It appears to be practicable to prevent the pollution of this source by diverting the drainage from the limited number of buildings on the water-shed away from the pond.

It appears from the recent examination that the conditions are somewhat worse than at the time the previous examination was made. It would apparently be practicable, at small expense, to divert away from the pond the drainage from the buildings mentioned; and if this should be done, the ice from this source might, in the opinion of the Board, safely be used for domestic purposes.

The other pond is located near Jarvis Avenue, in Holyoke, not far from Cherry Street. This source has already been examined by the Board, in response to an application from you on Dec. 18, 1900, for advice as to its use as a source of water supply; and the Board advised you, on Jan. 21, 1901, as follows: —

> In response to your application of Dec. 18, 1900, for advice as to whether the water of the stream known as Crystal Spring, used to supply about five hundred residents of the district known as Elmwood, in Holyoke, is suitable for domestic use, the Board has caused the source to be examined by one of its engineers and a sample of the water to be analyzed.
>
> The results of the analysis show that the water at the present time, while somewhat hard, is nearly colorless, and contains but little organic matter. An examination of the water-shed shows that near its upper end there are two dwelling houses and a building which has been used in the past as a small-pox hospital for the city of Holyoke; but for several years no cases have been treated at this place, though the building is maintained ready for use. It does not appear that polluting matters are entering directly any of the streams in the water-shed at the present time, and, in the opinion of the Board, the water at present is suitable for domestic use.
>
> It is exposed, however, to possible danger of serious pollution from the buildings on the water-shed; and if the use of the source is to be continued, it will be necessary to see that all polluting matters from any of these buildings or from any of the farming operations within the water-shed are kept out of the streams at all times; and especial care should be taken, in case any contagious or infectious disease should appear on this water-shed, to prevent danger to the water supply therefrom.

An analysis of a sample of ice collected recently from this pond shows that it contains considerable organic matter; but, in the opinion of the Board, this pond may safely be used as a source of ice supply for domestic purposes, if polluting matters from the buildings on the water-shed are kept out of the pond.

LITTLETON.

JULY 7, 1904.

To the Board of Health of the Town of Littleton, MR. J. N. MURRAY, *Secretary*.

GENTLEMEN: — In response to your request, received May 24, for advice as to the use of ice for domestic purposes taken from Mill Pond, so called, in Littleton, the Board has caused the pond and its surroundings to be examined, and has caused a sample of the ice from an ice house located near the northerly end of the pond, from which, the Board is informed, ice is supplied for domestic purposes in Littleton, to be analyzed.

The results of the examination show that the ice, as harvested, contained a thin layer of snow ice at the top, but that otherwise the ice was clear and apparently free from foreign matter. The chemical and bacterial analyses show that the clear ice contains very little organic matter or bacteria; and, in the opinion of the Board, the clear ice may safely be used for domestic purposes. The snow ice should be completely removed before using.

MILTON.

APRIL 7, 1904.

To the Board of Health of the Town of Milton.

GENTLEMEN: — The State Board of Health received from you on Feb. 17, 1904, an application requesting an examination of the Pope and Turner ponds on Pine Tree Brook, used as sources of ice supply, and of the ice harvested therefrom, and in response to this request has caused these sources to be examined and samples of the water and ice to be analyzed.

The results of the analyses show that Pine Tree Brook receives considerable pollution, but the ice from the ponds indicated, while containing a somewhat larger quantity of organic matter than is usually found in good ice, was found upon examination to be clear and apparently free from particles of foreign matter, and bacterial examinations showed that very few bacteria were present. It was found that some of the ice harvested contained a thin layer of snow ice.

In the opinion of the Board, the clear ice harvested from these sources during the past winter may safely be used for domestic purposes. It is important that the snow ice be removed, and it is also important that all pieces of ice containing particles of foreign matter should be rejected.

NANTUCKET.

JULY 11, 1904.

To MR. JAMES H. GIBBS, *Nantucket, Mass.*

DEAR SIR: — In response to your request of June 17, for advice as to whether the waters of Maxey's Pond and the north head of Hummock Pond are fit for drinking, and whether the ice from these ponds is fit to be used for family use, the Board has caused the ponds and their surroundings to be examined by one of its engineers and samples of water and ice from these ponds to be analyzed.

The ponds are located in an uninhabited region, and their water-sheds are free from population. The soil about them is sandy, and evidently very little water reaches them by direct flow over the ground.

The results of the analyses show the presence of considerable organic matter, evidently caused by the presence of plants and microscopic organisms in the water; but there is no reason to think that these waters are unsafe for drinking, though they may at times have an objectionable taste and odor.

The ice found in the ice houses upon the shores of these ponds contains particles of the vegetable matters present in the pond when the ice was formed; but the ice is in other respects of good quality and, in the opinion of the Board, this ice is safe for domestic uses.

PALMER (THREE RIVERS).

JULY 11, 1904.

To the Board of Health of the Town of Palmer, J. P. SCHNEIDER, M.D., *Chairman*.

GENTLEMEN: — In accordance with your request of June 13. for an examination of the ice sold in Three Rivers, Palmer, for domestic purposes, the Board has caused samples of ice at present in store in an ice house near the Quaboag River in Three Rivers, which the Board is informed was harvested from that river during the past winter, to be analyzed.

The Quaboag River drains a large area, and receives the sewage of Palmer, three miles above Three Rivers, beside much other pollution. A sewer from the village of Three Rivers discharges into the stream opposite the place from which the ice is cut.

The ice examined was found to consist of about six inches of clear ice and five inches of snow ice. evidently formed above the clear ice by rain or flooding. The results of an analysis of a sample of this ice show that the snow ice contains a large quantity of organic matter, and that the clear ice contains more organic matter than is found in good ice.

Considering the circumstances, the Board cannot regard this ice as safe for use where it may come in contact with food or drinking water.

QUINCY.

MARCH 3, 1904.

To the Board of Health of the City of Quincy.

GENTLEMEN: — In response to your application for an examination of the ice harvested from Furnace Pond by the Eaton Ice Company during the present winter, and advice as to its quality for domestic purposes. the Board has caused several examinations to be made while the ice was being harvested from this source, and several samples of the ice to be analyzed.

The results of the examinations show that the ice was planed or shaved before storing, and the snow ice and a considerable depth of the ice which first formed upon the pond were removed. and pieces of ice containing foreign matter were rejected. A considerable quantity of grass and other débris was floating in the water of the pond when ice first formed upon it, and was included in the first crop of ice; but nearly all of this floating material was subsequently removed from the ice by planing or shaving off a depth of several inches before storing it in the ice houses. The ice of this first crop. excepting portions containing foreign matter, was of good quality.

Analyses of several samples of the ice of subsequent crops show that the number of bacteria present in this ice is not large, and none of the bacteria characteristic of sewage was found in the samples analyzed.

Under the circumstances, the Board is of the opinion that ice harvested from Furnace Pond during the present winter may safely be used for domestic purposes, provided that ice containing pieces of wood, leaves, grass or other foreign matters be excluded.

Westport.

July 21, 1904.

To the Board of Health of the Town of Westport.

Gentlemen: — The attention of the State Board of Health has been called to the condition of a pond on the Noquochoke River, situated in the village at the head of Westport River, the water of which is said to have been polluted by the discharge of sewage from mills upon the stream above during the past winter, when ice was harvested therefrom.

The Board has caused the locality to be examined by one of its engineers, and finds that the water entering this pond is polluted by the direct discharge into the stream of water-closets and privies in two factories, one of them within about a quarter of a mile and the other within about a mile above the pond.

An analysis of a sample of ice taken from an ice house on the shore of this pond, which consisted of about ten and one-half inches in depth of clear ice with about one and one-half inches of snow ice on top, was found to contain considerable organic matter, and a much larger number of bacteria than is found in ice collected from unpolluted sources. The Board is informed that this ice is not used for domestic purposes, and, in the opinion of the Board, it should not be so used.

If the use of this pond as a source of ice supply is to be continued, the sewage from the factories referred to should be diverted from the pond, and collected in privies or cesspools so located that no sewage can find its way into any of the streams which feed the pond.

Sewerage and Sewage Disposal.

The following is the substance of the action of the Board during the past year in reply to applications for advice relative to sewerage and sewage disposal: —

Brockton.

March 3, 1904.

To the Sewerage Commissioners of the City of Brockton.

Gentlemen: — In response to your communication of February 12, stating that the limit of the capacity of your present works for purifying sewage has been reached, and desiring advice as to methods of increasing the capacity of the purification works, the State Board of Health has caused examinations of the present condition of the filtration area to be made, and has considered the information furnished by previous examinations and by the records of the operation of these works since they were first used.

The results of the examinations show that the capacity of the present filters for purifying thoroughly all of the sewage of the city of Brockton has practically been reached, and that additional capacity is required in order to provide adequately for the purification of the increasing quantity of sewage from the city.

The soil in areas adjacent to the sewage filter beds was examined very thoroughly by this Board previous to the construction of the present works, the results at that time showing that the best land in the vicinity of the present area for the extension of the filter beds was situated just west of them, within the limits of the town of Easton, this land being similar in character to that where the filter beds are now located, and superior in topography, character of soil and distance from habitations to land either east or north of the filter beds. These conditions have not changed in the years since that examination was made, and filter beds constructed on this land would be located farther from dwelling houses than the present filter beds.

In the opinion of the Board, the best practicable plan of increasing the capacity of the works for purifying the sewage of the city of Brockton is to construct additional filter beds upon the land in the town of Easton adjacent to the present filter beds, on their westerly side.

FAIRHAVEN.

AUG. 4, 1904.

To the Board of Sewer Commissioners of the Town of Fairhaven, Mass., MR. E. G. PAULL, *Chairman.*

GENTLEMEN: — The State Board of Health received from you on July 26 the following application for advice with reference to a proposed system of sewerage for the locality known as Oxford Village, in the town of Fairhaven: —

> The general plan is as shown with an outfall into "Acushnet River," so called, at the southerly end of Cherry Street. The outfall will be of iron pipe, carried out as far as may be deemed advisable. Sewers on the combined system are contemplated.
>
> Of course the commissioners realize the lack of current in the immediate vicinity of Cherry Street, but by carrying the outfall out as above suggested, it is believed that the sewage will be diluted so as not to create a nuisance on the shore.
>
> The general character of the soil in the district proposed to be sewered is gravelly, mixed with sand. The soil is extremely absorbent except near Cooke Street, where the hardpan is of great detriment to construction of satisfactory cesspools, and it is mainly the residents on this street who have pushed the matter of sewerage.
>
> Good grades are obtainable in all streets shown on plan.

> The water-shed east of Main Street is only shown very approximately, from a mere cursory inspection of the territory. The land is so nearly level and so very absorbent that it was not deemed necessary to make a topographical survey.
>
> The sizes of pipe are based on an estimate of 25 acres, more or less, of impervious area as streets and houses in the future.
>
> The present population of the district may be 300; but this section of the town is bound to increase rapidly in the next ten or fifteen years.
>
> It is purposed this year to put in the trunk sewer in Cherry Street, and run through Cooke and Main streets, as shown in full lines. Next year the full line system will probably be completed, and there may be further extensions.

The application was accompanied by a plan of the projected sewer system for Oxford Village and of the proposed outlet, located at a point in New Bedford harbor about 250 feet from the shore at high water.

The Board has already considered a plan of sewerage for this village at a previous time, when it was proposed to discharge the sewer near Cooke Street; and at that time advised you as follows: —

> It is probable, in the opinion of the Board, that, if the outlet of the proposed Cooke Street sewer should be carried farther to the south, to some point opposite the end of Oxford Street, or between there and the end of West Street, where deeper water can be reached at no great distance from the shore, the small quantity of sewage which this sewer will receive can be discharged into the harbor for a time without creating a serious nuisance. Sewage can be brought to this place by a pipe laid along the shore, or possibly by a sewer which would pass part of the way through private lands between North Street and Oxford Street. It is desirable, in the opinion of the Board, to keep storm water out of this sewer, and to dispose of the storm water by a separate channel, since this water, if unpolluted by sewage, can be discharged into the harbor at any convenient place without creating objectionable conditions.
>
> In the opinion of the Board, it would be of much advantage to the town, since other sewers seem likely to be required for small sections in the northerly part of the town before long, to prepare a general plan for the sewerage of those portions of the town not now provided with sewerage. When such a plan has been prepared and a suitable outlet for the sewage selected, it will be possible to build local sewers from time to time, with temporary outlets, if suitable outlets can be found, in such a manner that these sewers can form part of a general system at some future time.

The Board has caused the locality to be examined by its engineer, and has considered the plan and the description of the proposed system.

The outlet now proposed, instead of being located near the point in the neighborhood of Oxford or West streets, as suggested in the communication of the Board quoted above, is located in the cove farther south, toward which the prevailing winds blow in summer; and, there being little or no current in this part of the harbor, floating matters deposited in the waters in the neighborhood of the proposed outlet would be carried quickly to the shore.

It would be practicable to carry the outlet farther west than the location now indicated, and to discharge the sewage into deep water off the point beyond West Street, where it is likely that this sewage can be discharged for a time without seriously fouling the water or the shores in the neighborhood; and the Board would advise that, if sewage is discharged into the harbor in this region, it be discharged at an outlet located off the point indicated, well beyond the shore at low tide.

The plan submitted is also objectionable in that provision is made for taking storm water into the sewers. It is likely that, if the population in this region grows rapidly, as now seems probable, it will be necessary to remove the sewage to some more suitable outlet farther south; and this can be done more economically if the sewers are built upon the separate plan than if they receive both sewage and storm water. Moreover, the storm water can be disposed of at convenient points on the shore, by means of comparatively short channels; and it will probably be less expensive to construct the works if the sewage is kept separate from the storm water, than by employing the combined system. The Board would, therefore, advise that the sewers be built for sewage only, and that the storm water be discharged through separate channels.

FALMOUTH.

MARCH 3, 1904.

To the Board of Health of the Town of Falmouth.

GENTLEMEN: — The State Board of Health received from you on February 18 plans of a proposed system of sewerage for the village of Falmouth Heights, which provide for collecting the sewage in a separate system of sewers, discharging into Vineyard Sound at two outlets, one at the westerly end of the village near Bowman's Pond, and the other at the easterly end of the village near Little Pond. It is proposed to locate the outlets about 100 feet beyond low-water line, where there is said to be a depth of about 8 feet of water at low tide. The principal part of the sewage of the village would, by this plan, be discharged at the easterly outlet, the westerly outlet being designed to serve only a few houses on the westerly slope of the hill.

The Board has caused the locality to be examined by one of its engineers, and has considered the proposed plan. No profiles or plans showing the slopes of the proposed sewers have been submitted, and the Board is unable to advise whether or not the proposed sewers are of adequate capacity for the removal of all of the sewage of the area which they are designed to serve.

The proposed outlets are objectionable on account of their nearness to shore, and the danger that solid matters from the sewage may be carried upon the beach, which, it is understood, is used for bathing by large numbers of people in the summer season. The westerly outlet seems likely to be the more objectionable of the two. The number of houses which will be connected with the proposed sewer discharging at this outlet is small, and the sewage of these houses could probably be disposed of by cesspools without special difficulty or objection, until the locality becomes more densely populated.

No information is submitted to show the direction of the currents at different stages of the tide, and the Board is unable to advise as to the probable movement of the sewage if discharged at the proposed easterly outlet. There seems to be much danger, however, that floating matters from the sewage might be carried to the shore; and, if the sewage is to be discharged into the sound at this place, the Board would advise that the sewer outlet be carried out to a point at least 200 feet from the shore at low water, and that the sewage, before being discharged, be passed through a tank for the removal of floating matters. It would be practicable to purify this sewage upon land not far from the village, and avoid discharging it into the sea; but it would be necessary in that case to pump the sewage, and the cost of the works would be greater than the cost of discharging it into the sound. If the proposed outlet should become objectionable, however, the sewage could be disposed of on land.

GRAFTON (COLONY FOR INSANE).

AUG. 4, 1904.

To the Trustees of the Worcester Insane Hospital, E. V. SCRIBNER, M.D., *Superintendent.*

GENTLEMEN: — The State Board of Health has considered your plans for the disposal of the sewage from buildings of the Grafton Colony of the Worcester Insane Asylum, in Shrewsbury, Grafton and Westborough. These plans provide for the disposal of the sewage of the women's building and power plant upon sand filter beds in Grafton, adjacent to the boundary line between Shrewsbury and Grafton, about 100 feet west of the boundary line between Grafton and Westborough.

The soil of this region, judging from surface indications and the material found in a test pit, is apparently composed of porous material, suitable for the purification of the sewage by intermittent filtration; and, in the opinion of the Board, it is probable that filter beds can be constructed in this vicinity upon which it will be practicable to purify efficiently the sewage of the buildings.

The plans show a small filter bed located south of the Boston & Albany Railroad tracks and about 800 feet south of the filter bed referred to above, which is to be used for the disposal of the sewage of several buildings in this neighborhood. A test pit dug at the location of these beds shows that the soil is very fine; but, judging from surface indications, the land farther down the hill near the railroad is composed of material suitable for the purification of sewage by intermittent filtration.

The sewage of a building located in the northerly portion of the area is also to be disposed of upon a sand filter bed. It would be practicable to convey the sewage into the sewer which removes the sewage from the power house and the women's building, and this may be the best plan of disposing of this sewage. The quantity of sewage to be disposed of from this building will be very small; and, unless the building is enlarged or others should be built in this neighborhood, it will probably be best to dispose of the sewage upon artificial filter beds near the building. There is no soil suitable for the purpose available in the neighborhood, but filters can undoubtedly be constructed by hauling sand or gravel from other portions of the land owned by the hospital.

No details of any of the proposed filter beds are shown on the plans submitted; and, as already indicated, the character of the soil at the place at which it is proposed to construct filter beds has not yet been examined sufficiently by means of test pits. The soil should be carefully examined before the sewers are built, in order that suitably constructed filter beds of ample area shall be provided at each place. When you have prepared further details of the plans of sewage disposal, the Board will, if you so request, advise you concerning them.

You have also requested advice as to the proposed water supply for the institution. Two sources have been indicated by you: one being a spring south-west of Green Hill and a short distance north of the water tower; and the other, springs near the Boston & Albany Railroad, south-west of the proposed sewage-disposal area. An analysis of the water of the first-mentioned spring shows that it is of excellent quality for drinking purposes, and the quantity flowing at the time the examination was made would be ample for the present requirements of the institution. The springs near the railroad are located at a much lower level; but it is probable that water of excellent quality can be obtained from the ground at this place, and in larger quantities than from the spring near the water tank. While a sufficient supply can doubtless be obtained for the present from the spring near the water tower, and the expense of obtaining a supply from that source would be less, the board would advise that the water of the springs near the railroad be also carefully protected from pollution, since that source is a desirable one, and is likely to be required at some future time.

GREAT BARRINGTON.

MARCH 3, 1904.

To the Sidewalk and Sewer Commissioners, Great Barrington, Mass., MR. JOHN K. SIGGINS, *Clerk.*

GENTLEMEN: — The State Board of Health received from you on Feb. 8, 1904, plans of sewerage for two small districts, containing together about forty dwelling houses, in the northerly portion of the village of Great Barrington, — one on the easterly and the other on the westerly side of the Housatonic River, — which provide for collecting the sewage into a system of pipe sewers, and for outlets into the Housatonic River above the Russell mill dam, so called. The sewer on the easterly side of the river will, according to the plan, discharge into the river about 350 feet above the dam and about 30 feet from shore; that on the westerly side will discharge into the river about 2,400 feet above the dam and about 30 feet from shore.

The Board has caused the conditions about the proposed outlets to be examined by one of its engineers; and having carefully considered the proposed plans, concludes that the discharge of sewage from the small areas indicated on the plan into the Housatonic River at the outlets shown is permissible under existing conditions, and advises the adoption of these plans for the disposal of the sewage from these areas. The Board would advise that in the construction of these sewers surface and roof water be excluded, and that in general in the construction of sewers in the town the separate system of sewerage be employed; since it may be necessary at some future time to remove all of the sewage from the proposed outlets and from the various existing outlets in the village to some place of disposal farther down stream, and in that case much expense would be saved if the storm water is kept separate from the sewage. The storm water can be discharged into the river or its tributary streams at convenient points in the village without causing objectionable conditions.

HAVERHILL.

Oct. 6, 1904.

To the Hon. Roswell L. Wood, *Mayor, Haverhill, Mass.*

Dear Sir: — The State Board of Health received from you on Sept. 3, 1904, an application for advice as to an outlet for a proposed system of sewers in the Front Street district, so called, in the section of the city formerly included in the town of Bradford, and for advice relative to proposed plans for relief of the present sewer system in ward 6, in the northwesterly portion of the city, by separating the sewage from the storm water in a portion of the district, and by providing an overflow for the relief of the sewers in other portions of the district, in time of rain, by discharging a part of the mingled sewage and storm water at such times into a mill pond on Little River or tributaries of that stream. The plans showing the details of the proposed method of collecting and disposing of the sewage in the latter areas were submitted with the application.

The proposed plans for the sewerage of the Front Street district provide for constructing sewers in substantial accordance with plans considered by this Board at a previous time, which provided for the construction of sewers to receive both sewage and storm water. It is now proposed, in constructing the outlet for this system, to discharge the dry-weather flow of sewage through a submerged outlet about 160 feet from the south bank of the river at ordinary high water, allowing the excess of flow of mingled sewage and storm water at times of storm to discharge at the edge of the river. The Board is informed that a sump, or sand-catcher, is to be placed in the bottom of the Front Street sewer above the upper end of the submerged outlet, to collect sand and similar materials which might tend to obstruct the pipe.

The Board has considered the plan of the proposed outlet, and has caused the locality to be examined by one of its engineers. It is very important, in the opinion of the Board, to discharge the dry-weather flow of sewage from this outlet at a considerable distance from the shore, since there is an eddy along the shore at this place, in which the sewage, if discharged at the edge of the stream, would be liable to collect and create a nuisance. There is no reason why a submerged outlet, as proposed, should not operate satisfactorily at this place if properly constructed, provided it receives the necessary care to insure the removal of sand from the sump and matters which might tend to clog the submerged pipe.

The territory considered in the proposed plans for changes in the sewerage and drainage system in the north-westerly part of the city is included approximately between Round Pond on the east and Little River on the west, and between Eleventh Avenue and Sheridan Street on the north, and John Street, Fourth Avenue and Howard Street on the south. This district includes nearly 350 acres, practically all of which is within the water-shed of Little River. The sewage of the district is at present removed in a marginal sewer, so called, in the valley of Little River, through which it is conveyed to the Merrimack River.

The southerly portion of this district is already served by a combined system of sewers, while in the northerly portion the sewers are constructed almost entirely upon the separate plan. It is now proposed to extend the separate system in the northerly part of the district to include about 162 acres, by discontinuing all connections through which storm water is now discharged into the sewers, and by providing at the same time a general system of storm-water drains to convey the storm water to a small tributary of Little River, allowing the sewage to flow as at present into the main sewer in the Little River valley.

It is proposed to divide the southerly portion into two parts of nearly equal size, in the northerly of which it is proposed to introduce gradually the separate system, while in the southerly portion the use of the combined system will be continued. By this plan the storm water in these two areas, comprising 184 acres, will in part continue to flow in the same channels with the sewage for the present; and, in order to obtain relief from the overflowing of the sewers in the low part of these areas at times of heavy rain, it is proposed to provide an outlet into Little River, through which the excess of flow of mingled sewage and storm water above the capacity of the main sewer in the Little River valley may be discharged into the mill pond on Little River.

The proposed overflow, as indicated upon the plans submitted, will run westerly from Primrose Street through a proposed street, and, after crossing Hale Street, will pass through private land under the Boston & Maine Railroad to the Little River. Between Primrose and Hale streets the outlet will have a diameter of 60 inches. It is proposed at the present time to build only the portion of this outlet lying between Primrose and Hale streets, and to extend a 36-inch pipe northerly in Hale Street to a small arm of Little River, and subsequently to extend the main outlet from Hale Street to the river, reducing its diameter to 44 inches. Storm-water overflows will be provided from the sewers which receive storm water, by which the excess of flow in the combined sewers in the district indicated will be discharged through this outlet at times of storm.

The Board has considered the plans and the information submitted, and concludes that there will be no objection to the discharge of storm water, if unpolluted by sewage, into Little River or any of its tributaries; but that, if any considerable quantity of sewage should be discharged into Little River, a serious nuisance would be likely to result. The district under consideration is not at present thickly populated, however, and it will be practicable, under existing conditions, by building storm-water drains, to prevent the overflow of sewage except in heavy storms and at infrequent intervals; and, if mingled sewage and storm water are discharged into Little River above the dam at Winter Street at such times only, the Board is of the opinion that objectionable conditions are unlikely to result. If the sewage should be discharged into the small arm of Little River east of the railroad, as proposed, a nuisance might be created.

The expense of extending the 60-inch sewer or drain directly to Little River at its full size in the beginning will not be greatly in excess of that of the plan now proposed; and, in the opinion of the Board, it is important that in this respect the plans be modified, and the drain be extended to Little River in the beginning. With this modification, the Board is of the opinion that the plan is an appropriate one for the sewerage of the district in question, and for removing the objectionable conditions now existing by the overflow from existing sewers in this area.

Nov. 3, 1904.

To the Board of Harbor and Land Commissioners, Mr. Woodward Emery, *Chairman.*

Gentlemen: — Since the receipt of your communication of November 1, the Board has caused the location of the proposed sewer outlet at Haverhill to be examined by its engineer, to determine whether any objection exists, from a sanitary point of view, to the discharge of sewage at the point indicated upon the plan submitted by you, — about 75 feet from the shore at high water; and finds that the bottom of the river in this region is somewhat uneven, and that a small area is exposed beyond the pipe at extreme low water.

Considering the circumstances, the Board is of the opinion that, if the sewer pipe should be extended 50 feet beyond the terminus indicated on your plan, objectionable conditions are unlikely to result.

HOLYOKE.

SEPT. 1, 1904.

To the Board of Public Works of the City of Holyoke.

GENTLEMEN: — The State Board of Health has considered your request for advice as to a modification of the plan for the disposal of the sewage of the Highland district, so called, in the city of Holyoke, and has caused the locality to be examined by one of its engineers.

The question of the disposal of the sewage from this district has already been considered by the Board in response to previous requests of the city of Holyoke; and, as the matter now stands, the plans which have been proposed by the city and the adoption of which has been advised by the State Board of Health provide for conveying this sewage through a sewer to be laid along the westerly bank of the Connecticut River to a junction with the Walnut Street sewer, so called, whence the sewage of both sewers is to be conveyed into a main sewer having an outlet into the Connecticut River below the city; so that, when these plans have been carried out and the necessary sewers have been built, all of the sewage of the city will be discharged below the dam.

You now request the advice of the Board as to a modification of this plan, and have presented a plan which provides for collecting the sewage of the Highland district at the head of the dingle, so called, — a ravine through which the surface water now runs to the Connecticut River, — and conveying it through a 10-inch iron pipe across the island which has formed near the westerly bank of the river to a point of discharge in the Connecticut River east of the island and about midway between the island and the South Hadley shore; and you request the advice of the Board as to the disposal of the sewage of the Highland district in this way for a period of from five to seven years, at the end of which time you propose to dispose of it in connection with the sewage discharged at the Walnut Street outlet, according to the plan outlined above.

The Board has carefully considered this plan, and concludes that sewage discharged at the proposed outlet would quickly mingle with the water of the river, and would not create a nuisance in the neighborhood; but the sewage-polluted water will be quickly carried into the canals in the city, whence it is drawn by the mills for various mechanical and manufacturing purposes, and is liable to be used for drinking.

The Board believes it important for the city to remove all of the sewage to some point of discharge below the Holyoke dam. The saving in expense to the city by constructing the temporary outlet now proposed and using it for a period of from five to seven years would not be great; and the Board believes the better plan for the city of Holyoke to adopt would be to convey the sewage in the beginning to a point of connection with the Walnut Street sewer, as provided in the plans presented to this Board in 1900.

HUBBARDSTON.

JULY 7, 1904.

To the Board of Health of the Town of Hubbardston, W. T. KNOWLTON, M.D., *Chairman.*

GENTLEMEN: — The State Board of Health has considered your request for advice as to the removal of certain unsanitary conditions in the village of Hubbardston, which you describe as follows: —

> At the present time the surface water from the main street of the town is collected into two main drains or ditches, and this is emptied onto private land. This land is low, and the water accumulates, forming a long, shallow body of stagnant water, within a very short distance of numerous wells used for drinking purposes. After a heavy rain the conditions are greatly aggravated. Certain wells at this time are unfit for use, owing to surface water which percolates into them. This condition has existed for a long time.
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> Now, I would like to ask if the Board will . . . look into this condition, and suggest a means to remedy the present nuisance. It is a constant source of menace to health, as there have been several cases of typhoid and a number of cases of intestinal disorders that have fallen under my notice.

In response to this application, the Board has caused the locality to be examined by one of its engineers and samples of water from wells in the locality indicated to be analyzed.

As a result of the examination, it appears that surface water from the northerly end of the village flows naturally to a swampy area, just west of the main street, and that drains have been constructed to convey the surface water to this area, which discharge not far from the westerly side of the street. The swampy area into which these drains discharge is bordered with dwelling houses not much above the level of the swamp, and sewage from these houses, as well as from others in the neighborhood, is discharged upon this area or into adjacent ditches. Attempts appear to have been made to drain the swamp, but the drains dug for this purpose are ineffective.

Analyses of samples of water from two of the wells near the edge of the swamp used as sources of drinking-water supply show that they are grossly polluted by sewage, and other wells in this locality are probably also seriously polluted by sewage.

It is evidently practicable to drain the meadow and prevent surface water from standing thereon and flooding the wells, and it is very desirable that this area should be drained, for sanitary reasons; but the soil in this region is very fine and nearly impervious to water, and a nuisance would probably continue to exist by reason of the disposal of sewage from the dwelling houses in this region, and some means of disposing of this sewage is also required.

A survey will be necessary to determine the best method of improving these conditions, and the Board would advise that you have an investigation made, and a plan for the drainage of this section and the disposal of the sewage prepared. When the results of further investigations are available, the Board will, upon application, give you further advice in this matter.

The most serious injury to health caused by the conditions now complained of is probably caused by the pollution of the wells in this neighborhood, and the Board would advise that the further use of water from these polluted wells be prevented at once. An examination of wells in other parts of the village of Hubbardston shows that many of them are badly polluted by sewage.

A public water supply is greatly needed in this village, and there are sources in its immediate neighborhood from which an adequate water supply could apparently be obtained with little difficulty and at a reasonable expense. Many villages of similar size are already provided with such supplies, and the Board would advise the town to take measures without delay to determine the probable cost of a public water supply, with a view to the introduction of such a supply as soon as practicable.

Lenox.

July 7, 1904.

To Messrs. H. D. Kendall, Richard C. Brine and T. F. Mackey, *Sewer Commissioners of the Town of Lenox.*

Gentlemen: — The State Board of Health has considered your application for advice with reference to enlarging the filtration area of the town of Lenox and the plans of the proposed new filters submitted therewith, and has caused the locality to be examined by one of its engineers.

The plans submitted provide for four filter beds, having an area of a little less than one and one-half acres, including the embankments. It does not appear that any preliminary examinations of the soil at the location of these filter beds were made; and from such information as the Board has collected, it appears that the soil is extremely fine, and not suited to the purification of sewage.

An examination of the ground on the slope of the hill not far from the location of the proposed filter beds shows that in some places at least the soil consists of gravel and sand of good quality for the purification of sewage by intermittent filtration, and it appears that some of this land is now used for the disposal of a small quantity of sewage by means of trenches.

The Board would advise that a careful examination of the soil in this region be made by means of test pits, to determine whether it is practicable to secure a sufficient area of land containing porous soil for the purification of the sewage of Lenox, so located that its use for purposes of sewage purification would not be objectionable. If it is not practicable to find such an area, investigations should be made to determine whether it will be practicable to construct a sufficient area of filter beds for the purification of the sewage by the use of suitable material obtained in some other locality.

The Board will, upon application, give you further advice in this matter when the results of further investigations are available.

SEPT. 1, 1904.

To Messrs. HENRY D. KENDALL, RICHARD C. BRINE and T. F. MACKEY, *Sewer Commissioners of the Town of Lenox.*

GENTLEMEN: — In response to your application of Aug. 8, 1904, in which you state you have made further investigations as to the disposal of the sewage of the town of Lenox, and now desire further advice from the Board as to the disposal of the sewage and as to the possible danger of the contamination of the water supply of the New York, New Haven & Hartford Railroad Company at Lenox station by sewage or effluent from the proposed works, the Board has considered the further information presented, and has caused a further examination of the locality to be made by one of its engineers.

It appears that test pits have been dug on the slope of the hill below the filter beds proposed in your last communication and that the soil found beneath a layer of loam in the northerly portion of the land owned by the town consists of gravel and sand suitable for the purification of sewage by intermittent filtration; but the layer of porous soil is underlaid by a stratum of fine material unsuitable for the purification of sewage, and the depth of the porous layer is in some places slight.

It appears, from the investigations, to be practicable to construct in this locality a limited area of filter beds of suitable character for the efficient purification of sewage by intermittent filtration; but the information furnished by your investigations is insufficient to make it practicable to determine whether a sufficient area of filter beds can be constructed by the use of the porous material in this locality to provide adequately for the purification of all of the sewage of Lenox. The cost of constructing filter beds from the porous material found in the northerly portion of the area now owned by the town would probably be large, since it would probably be necessary to move much of the material in order to secure filter beds of sufficient depth; and, considering the limited area of filter beds that could probably be made available at this place, it is desirable to make other investigations in this region, to determine whether filters of adequate area for the purification of the Lenox sewage cannot be constructed at some other place in this region at a less expense than on the area now in use.

The two filter beds recently constructed and now nearly completed contain soil so fine that water from the rainfall apparently remains upon the surface for a long time after the rain has ceased, indicating that little if any sewage would pass through these beds.

It is understood that you propose to lay underdrains 15 feet apart in these beds, and to refill the trenches over the underdrains with sand and gravel. If this should be done, these filters would pass some sewage, but their capacity would be limited by the area of the porous material over the underdrains.

The Board would advise that a further and more thorough investigation be made of the areas available for the purification of the sewage of Lenox; and, when further investigations have been made and plans for the disposal of the sewage prepared, the Board will, upon application, give you further advice in this matter.

An examination of the locality from which the water supply of the Lenox station is now taken shows that the source would not be likely to be affected by the disposal of sewage at the place now proposed; but, if the sewage should be disposed of on the porous soil near the northerly limits of the area owned by the town, it is possible that the source of water supply might be polluted by the sewage; and it is advisable, in the opinion of the Board, that, if the area indicated should be used for the disposal of sewage, the use of water from the present source of supply be discontinued and a supply secured from another source. It is probable that water could be obtained from some point farther up the valley.

LEOMINSTER.

APRIL 7, 1904.

To Messrs. A. L. WHITNEY, W. H. CHASE and C. H. HOWE, *Sewerage Committee of the Town of Leominster.*

GENTLEMEN: — On March 4, 1904, the State Board of Health received from you the general plans of a system of sewerage and sewage disposal for Leominster, which provide for collecting the sewage of all of the thickly settled portions of the town in a separate system of sewers, discharging by gravity upon filter beds bordering the north branch of the Nashua River on its south-westerly side, north of Mechanic Street, where it is proposed to purify the sewage by intermittent filtration.

The Board has already considered the propriety of using the area indicated for the disposal of the sewage of the town, and has advised your committee, under date of Nov. 5, 1903, that the proposed location was not objectionable, and that excellent material was available at this place for the construction of a sufficient area of filter beds upon the low land near the Nashua River to purify the sewage of the town.

The Board has considered the additional plans now presented, showing the proposed main sewers and further details as to the construction of the proposed filtration area, and finds them to be well adapted to the collection and efficient purification of the sewage of all of the thickly settled portions of the town.

The proposed settling tank at the filtration area is of sufficient size for the requirements of the town in the beginning, at least, and can be enlarged in future if necessary.

The area of filter beds shown should be ample for a long time in the future, and it will be necessary to prepare only a portion of this area in the beginning, if the storm water which is admitted to the present sewers shall be excluded, and care taken in the construction of future sewers to exclude ground and surface water so far as practicable.

In the opinion of the Board, works constructed in general accordance with these plans would provide satisfactorily for the collection and disposal of the sewage of the town of Leominster.

MANCHESTER.

JUNE 2, 1904.

To the Board of Health of the Town of Manchester, Mr. WILLIAM H. ALLEN, *Chairman.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to the disposal of night soil in Manchester by discharging it upon a certain tract of land north of Lincoln Street, and has caused the locality to be examined by one of its engineers.

The results of this examination show that the area which it is proposed to use is located about 600 feet from your present sources of water supply, and at a higher level; and, while some tests have been made in this neighborhood to show the depth to ground water, it is impracticable to determine, from the information now available, whether leachings from night soil deposited upon this area would flow in the direction of the wells and affect the quality of their waters, or not.

It is essential to avoid the possible danger of the pollution of your sources of water supply; and, under the circumstances, the area indicated should not, in the opinion of the Board, be used as a place of disposal for night soil. An area should be secured, as you have already been advised, at some place where this material can be disposed of without danger of affecting your sources of water supply.

This matter can be disposed of without objection by dumping it at sea, provided it is conveyed to a sufficient distance from any shore so that it may become mingled with the water and completely broken up before it can return; and the plan of disposing of the night soil in this way, until such time as a sewerage system is available, will probably be the least objectionable one to adopt.

MARBLEHEAD.

APRIL 7, 1904.

To the Sewerage Committee of the Town of Marblehead.

GENTLEMEN: — The State Board of Health received from you on March 30, 1904, an application for further advice relative to the sewerage of the town of Marblehead, accompanied by plans showing a system of sewers having an outlet about 400 feet south-east of Tinker's Island, and by a report giving an estimate of the cost of the disposal works, together with observations of the movements of floats at the proposed point of discharge, as suggested in the communication of this Board on June 4, 1903; and the Board has carefully considered the modified scheme now submitted.

Sewage discharged south-east of Tinker's Island would not be noticeable from the mainland, and there is apparently a considerable tidal current setting between the island and the shore of the mainland which would have a tendency to keep floating matters from returning upon these shores; and the limited number of float experiments made all show that the floats moved in a direction parallel with the shore, none of them showing a tendency to come upon it. The outlet proposed is a very favorable one for the disposal of sewage, and, in the opinion of the Board, the sewage of Marblehead can be effectually disposed of by discharge into the sea at the point indicated, — 400 feet or more south-east of Tinker's Island, — without danger that the sewage will return to the shores of the mainland or create a nuisance anywhere.

The further investigations as to the sewerage of the town have shown that it is practicable to collect the sewage of the greater portion of the town at a point near the south-easterly shore of Marblehead Neck by gravity. It appears to be necessary to omit from this plan a low area in the extreme north-easterly end of the town, including a portion of the main village; and the plans provide for collecting the sewage of this area at a reservoir and pumping station to be located at the shore of Little Harbor, near the gas works, from which it is to be pumped into the main system.

A small area in the extreme south-westerly part of the town, adjacent to the town of Swampscott, has been omitted from the present plan, as was the case last year, since it would be less expensive to pump the sewage of this area into the main sewer, when sewerage becomes necessary, than to lay the main sewer in this region at a sufficiently low level to serve this area. There is a similar low area in Swampscott, adjacent to the Marblehead area, which cannot be served by gravity by the Swampscott sewers; and it may be possible for the two towns to effect some joint plan of collecting and disposing of the sewage of these areas which will be less expensive than the collection and disposal of the sewage by each town separately.

While it is necessary, under the plan now proposed, to maintain two pumping stations, the estimates of cost submitted by your engineer indicate that the expense of collecting and disposing of the sewage of Marblehead into the sea off Tinker's Island in a satisfactory manner would be materially less than the cost of disposal in the neighborhood of Gray's Rock, should it be practicable to find a desirable outlet in that locality.

The plan in general, in the opinion of the Board, provides a practicable method of collecting and disposing of the sewage of the town of Marblehead in a satisfactory manner. When further details of the proposed system have been prepared, the Board will, upon application, give you further advice concerning them.

NORTHAMPTON.

MARCH 7, 1904.

To Mr. THEOBALD M. CONNOR, *City Solicitor, Northampton, Mass.*

DEAR SIR: — In response to your communication of March 3, requesting, on behalf of the city of Northampton, an extension of time for compliance with the present requirements for the extension of its sewers to the Connecticut River, in order that the city may investigate other schemes or plans, the State Board of Health directs me to inform you that it will grant such extension for a period of one year from Dec. 1, 1904, provided the city authorities of Northampton display due diligence in prosecuting the investigations as to modifications of the plans.

DEC. 1, 1904.

To Mr. THEOBALD M. CONNOR, *City Solicitor, Northampton, Mass.*

SIR: — The State Board of Health received from you on November 28 the following request for approval of certain plans for the disposal of sewage of the city of Northampton: —

> The undersigned, for the city of Northampton, respectfully presents the report of its engineers upon the question of sewage disposal, and hereby respectfully requests the approval of your Honorable Board of the first project for sewage disposal contained in said report, commencing with the last paragraph on page 8 of said report and ending with the first paragraph on page 15 of said report, — the same being contained in the report of Allen Hazen; and more particularly, first, for the location of a storm overflow to Mill River, at a point 1,200 feet more or less below the Wright Avenue bridge, to take the place of the present objectionable overflows at Wright Avenue bridge and at Williams Street; and, second, for the use of the present outlets to Mill River below the inhabited portion of the city for the dry-weather flow of sewage for a further period of ten years from Dec. 1, 1905.

Your application is accompanied by reports by Messrs. Allen Hazen and Ernest W. Bowditch, civil engineers, relative to the sewerage system of the city of Northampton, and by plans showing various methods of sewage disposal, including the project referred to in your application.

The sewerage system of the city of Northampton, constructed under the provisions of chapter 354 of the Acts of the year 1888, has been extended over the greater part of the built-up portion of the city, part of the system receiving sewage only, but a large part receiving both sewage and storm water. The area served by the combined system amounts, according to your engineers, to about 760 acres; and, in addition to the surface water received from this area, roof water from about one-half of the roofs of the houses of the city is also taken into the sewers.

In addition to the pollution which the river receives above the main sewer outlets from the overflow of sewage from combined sewers at times of rain, the sewage from practically all of the factories along the river, in which about 1,270 operatives are employed, is discharged into the stream, and additional pollution is caused by the discharge of manufacturing wastes from many of the mills. The stream is very offensive in the warmer portion of the year, from the neighborhood of the Wright Avenue bridge to the Connecticut River.

The Board, in 1903, approved the plan of constructing a sewer to remove the sewage and other pollutions from this portion of the river to the Connecticut River. The plan of relief mentioned in your application is intended as a substitute for this sewer. This plan is more fully described in the report of your engineer, as follows: —

> Extend the 4-foot sewer as a 54 and 60 inch sewer at a flatter grade from Wright Avenue through Pleasant Street, to a point about 300 feet below Meadow Street. At this point provide a large overflow to Mill River, carrying it well into the thread of the stream. Connect with the present 24-inch sewer to the present lower outlet, and allow the dry-weather flow to go in that way. Require Belding & Brothers' silk mill to connect with the existing sewers, and clean up the brook leading to the river just above Wright Avenue bridge. Clean up the channel of the river from the overflow below Meadow Street to the Connecticut River, removing obstructions, and giving as direct a channel as possible.

The only material change in the present condition of the river which would be effected by this project would be the removal of the pollution of the river in the neighborhood of the Wright Avenue bridge now caused by the manufacturing wastes from the Belding & Brothers' silk mill and the overflow of sewage from the main sewer. A new overflow would be created about 300 feet below Meadow Street, the discharge from which would be somewhat less than from the present overflow if the King Street brook should be diverted north-easterly toward the Connecticut River, as suggested. By the expenditure of $2,000 in cleaning the main stream and improving Mill River between the sewer outlets and the Connecticut River, the débris of various sorts which now clogs the bottom and sides of the stream could be removed and the channel improved to some extent; but the condition of this portion of the river, which is offensive throughout its length, and through which there is very little flow of water to dilute the sewage — especially at night or on Sunday — in warm weather, would continue to grow worse as the population of the city and the quantity of sewage and manufacturing waste increases.

The carrying out of the proposed plan would not, in the opinion of the Board, effect a material improvement in the objectionable conditions now existing in Mill River; and the Board is unable to approve the proposed plan as a substitute for the plan approved last year for diverting the sewage from Mill River to the Connecticut River.

A second project, described by your engineer, provides for conveying the dry-weather flow of sewage to the Connecticut River in a pipe 24 inches in diameter, which would have a carrying capacity estimated by your engineers to be between 5,000,000 and 6,000,000 gallons per day. If the sewers of the city had been constructed on the separate plan, a sewer of smaller size than the one approved by this Board in 1903 would be sufficient for the removal of the sewage of the city to the Connecticut River; and if the system should now be changed gradually, so that the sewage would ultimately be kept separate from the storm water in all parts of the city within the next ten years, it would be reasonable to build a smaller sewer at present; but the sewer proposed in the second project, described in your engineer's report, would be no more than sufficient for the present dry-weather flow of sewage for the city, and it is not unlikely that the dry-weather flow of sewage would exceed its capacity at times when the ground-water levels are high. The Board cannot approve the construction of a sewer of the size proposed as a substitute for the one already approved.

It appears from the investigations of your engineers that it would be practicable to convey the sewage from about four-fifths of the population of the city to the low lands bordering the river, and dispose of it by applying it to the land; but that the cost of disposing of the sewage in this way would be considerably greater than the cost of conveying it to the Connecticut River through a sewer of adequate size.

The plans submitted do not show a practicable way of preventing further serious pollution of Mill River at less expense than by the construction of the sewer approved by the Board last year, and which, by the requirements of the statutes, is to be constructed before Dec. 1, 1905.

It is very desirable, in the opinion of the Board, to keep the sewage out of Mill River, and this can be done by separating the sewage from the storm water in areas served by combined sewers, by diverting the roof water from the sewers, and by causing the factories and mills to discharge their sewage into the sewers and continuing the sewers to the Connecticut River. If the city desires to provide for the gradual separation of the sewage from the storm water within a definite period, the Board will consider the approval of a plan for the immediate construction of a sewer of smaller size than the one approved last year.

NORWOOD.

AUG. 10, 1904.

To the Board of Selectmen of the Town of Norwood, MR. FRED L. FISHER, *Chairman*.

GENTLEMEN: — On Sept. 19, 1903, your Board was notified of the order of the State Board of Health prohibiting all persons from discharging or permitting the entrance of sewage into any part of the Neponset River or its tributaries, and from discharging or permitting the entrance therein of every other substance which may be injurious to the public health, or may tend to create a public nuisance, or to obstruct the flow of water, including all waste or refuse from any factory or other establishment where persons are employed, unless the owner thereof shall use the best practicable and reasonably available means of rendering such waste or refuse harmless.

It now appears, upon further examination, that nothing has been done to remove from the river the sewage discharged into the stream at Dean Street from a sewer of the town of Norwood.

The State Board of Health, in accordance with a request from the authorities of the town of Norwood, in 1901, for advice as to the best practicable method of disposing of the sewage of the town, advised the purification of this sewage upon land south of the Neponset River, not far from the ink works in Norwood. This plan is described in the report of the committee on sewerage for the town of Norwood in 1901; and by constructing such portion of the main sewer as is necessary to divert the sewage from the present sewer and carrying it to the filtration area, and building a sufficient area of filter beds for the proper purification of this sewage, the further pollution of the river can be prevented; and this, in the opinion of the Board, is the best practicable and available plan of preventing the further pollution of the river by this sewer. It is practicable for the town, by proceeding diligently with the work, to complete the construction of the necessary works within the next four months.

The State Board of Health hereby notifies the town of Norwood to cease from discharging unpurified sewage from the Norwood sewer into the Neponset River or any of its tributaries on and after July 1, 1905.

NORWOOD (WINSLOW BROTHERS & SMITH COMPANY).

JULY 7, 1904.

TO WINSLOW BROTHERS & SMITH COMPANY, *Norwood, Mass.*

GENTLEMEN: — The State Board of Health received from you on June 3, 1904, an application for advice with reference to plans of proposed settling basins and filter beds for your tannery at Norwood, concerning which you make the following statement: —

> These plans apply to our Winslow Plant and we feel that they are large enough to care for our sewage for a number of years to come. About a year ago this time, after very careful measurements, we found the average amount of sewage matter to be four hundred and fourteen thousand gallons (414,000) per day of ten hours and at that time our plant was running at its full capacity. We have added somewhat to our plant since then but we feel confident that the increase in the amount of water used is not over twenty thousand gallons per day. In regard to increasing the capacity of our sewerage plant, we can build additional settling basins either to the north or south of those shown on the plan and in the area covered by the title and designated as "Bog" we can by simply filling, construct from three to four acres more of filter beds.

Two plans were submitted with the application, one showing the details of the proposed settling basins, and the other the general plan of the settling basins and filter beds, including the location of a collecting well or basin and pump, by which all of the sewage is to be pumped to the filtration area.

The Board has caused the locality to be examined by its engineer, and has considered the plans submitted by you and the results of investigations as to the quantity and character of the manufacturing wastes discharged from this plant in previous years.

It appears from the measurements of the quantity of foul wastes flowing from this tannery, presented by you, that there was a considerable increase in the quantity of such wastes from 1901 to 1903; and you estimate that there has been an increase of 20,000 gallons per day in the past year, making the quantity of foul wastes flowing from the tannery at the present time about 434,000 gallons per day. In addition to this quantity, a large quantity of water is used in the rinsing of wool after scouring, and some of this water is considerably polluted; but the Board is informed that it is proposed to use this rinse water hereafter in the other processes, so that no polluting drainage will be discharged into Hawes Brook from your works.

The proposed settling tanks indicated upon the plans submitted are six in number, and have an aggregate capacity of 562,500 gallons, the capacity being such that, with one tank out of use for cleaning, the sewage will be about a day in passing through the tanks. No provision has been made, however, for removing the solid matter from these tanks, other than by carting it away after it has been allowed to dry for a time; and, under the circumstances, there are likely to be times when more than one of the tanks will be out of use, and the sewage will pass through the tanks more rapidly than proposed. It is practicable to construct sludge beds upon the boggy area near the settling tanks, using gravel and sand from the adjacent upland, and to empty the tanks upon such beds by gravity as frequently as might be found desirable; and the tanks could be operated more efficiently and economically under such conditions than by the plan now proposed. The Board would advise that the design of these tanks be modified, that sludge beds be constructed upon the low area indicated, and that adequate provision be made for emptying the tanks upon the sludge beds whenever necessary. An area of 2 acres of sludge beds will probably be sufficient in the beginning, but experience may show that there would be advantage in the use of a larger area.

Examinations of the soil of the area upon which it is proposed to locate the filter beds have shown that much of it is very coarse and porous, and well adapted to the purification of the wastes from this tannery in the condition in which they have been found by investigations made by this Board in previous years.

Underdrains are shown beneath each of the beds, but the depth of these drains is not indicated. The underdrains should be laid at least 5 feet below the surface of the filter beds. It is probable that the underdrainage indicated will be sufficient, provided care is taken in laying the drains, to allow the effluent to enter them freely, and prevent their being clogged by sand or other material washed in through the joints.

The total area of filter beds indicated upon the plan is insufficient for the purification of all the wastes discharged from this tannery, and, in order to secure efficient purification of these wastes, a larger area will be necessary; and the Board would advise that at least 8 acres of filter beds be constructed, and provision made for further enlargement of the area whenever necessary.

AUG. 10, 1904.

To the WINSLOW BROTHERS & SMITH COMPANY, *Norwood, Mass.*

GENTLEMEN: — On Sept. 19, 1903, you were notified of an order of the State Board of Health, acting in accordance with the provisions of chapter 541 of the Acts of the year 1902, prohibiting all persons and corporations from discharging or permitting the entrance of sewage into any part of the Neponset River or its tributaries, and from discharging or permitting the entrance therein of every other substance which might be injurious to public health or might tend to create a public nuisance or to obstruct the flow of water, including all waste or refuse from any factory or other establishment where persons are employed, unless the owner thereof shall use the best practicable and reasonably available means to render such waste or refuse harmless; and on July 7, 1904, the Board, in further compliance with the provisions of the above-mentioned act, advised you as to certain plans for purifying the sewage and manufacturing waste and refuse from your factory, submitted by you on June 3, 1904, advising that tanks and filters built in accordance with the proposed plans would purify efficiently the sewage and waste liquors from this tannery, if certain changes should be made in the proposed settling tanks, provided an area of as much as 8 acres of filter beds should be constructed, instead of 6, as proposed.

On July 20, 1904, the Board received from your engineer a communication submitting plans showing a change in the location of the settling tanks; and the Board, after an examination of the plans of the proposed tanks as now arranged, finds that they are of adequate size and capacity for the present requirements of the works, and are so located that the liquid sludge in them can be discharged upon sludge beds built upon the low area of land adjacent to the brook and formerly used as a cranberry bog. By building sludge beds on this area, having an area of about 2 acres, as advised, with pipes for discharging such liquid matters from the settling tanks as will readily flow upon the sludge beds, the settling tanks can be emptied and cleaned as often as may be necessary for the removal of as much of the solid matter as it is practicable to remove from these waste liquors before applying them to the filters.

With the modifications indicated, the Board is of the opinion that the plan of collecting these wastes, pumping them to settling tanks and discharging the effluent upon about 8 acres of filter beds, as proposed, is the best practicable means now available of rendering the waste and refuse from this tannery harmless and preventing the pollution of the Neponset River; and you are hereby notified to cease, on or before July 1, 1905, from discharging the sewage and manufacturing wastes from your factory into Hawes Brook as at present until these wastes have been rendered harmless, as required by the provisions of the act.

PITTSFIELD.

NOV. 3, 1904.

To the Board of Public Works of the City of Pittsfield.

GENTLEMEN: — This Board has received communications recently from Mr. James Fallon, who states that he is the owner of lands adjacent to the southerly side of the Pittsfield sewage-disposal area, claiming that his property is injured by drainage from the filter beds flowing upon the low lands near the river, and especially by scum blowing from the filter beds in summer. From an examination of the locality it appears to the Board that the complaint that scum of dried sludge blows from the filters over the land in question is well founded, since a considerable quantity of such matter was found upon the fields south of the filter beds. There are also indications that drainage from the filter beds finds its way to these lands. The Board brings the matter to your attention for such action as you may deem proper.

ROCKLAND.

SEPT. 1, 1904.

To the Board of Health of the Town of Rockland.

GENTLEMEN: — In response to your request for an examination of a locality in Rockland where difficulty has been experienced on account of the overflow of cesspools, and advice as to disposing of the sewage, the Board has caused the locality to be examined by one of its engineers.

It appears that the trouble experienced occurred in the neighborhood of the corner of Blanchard and Church streets, where the cellars of three houses have been flooded with polluted water apparently derived from a neighboring cesspool. It further appears that after stopping the leakage from a water pipe which was finding its way into a drain on Blanchard Street and apparently thence into the cesspool, the level of the water in the cesspool quickly lowered, and the water disappeared from the cellars of the dwellings which had been flooded.

It seems probable, from an examination of the locality, that the trouble complained of was caused largely by the water leaking into the cesspool from the water pipe, and, the leak having been stopped, it seems unlikely that further similar difficulty will occur, though it is possible that an excessive quantity of water may find its way into the cesspool in very wet weather, unless a drain shall be provided to remove the ground water from its neighborhood.

It is evident, from an examination of the conditions in this region, as well as in other portions of the thickly settled area of Rockland, that a sewerage system is greatly needed, in order to avoid trouble such as that which has been complained of and to avoid the pollution of local water courses; and the Board would advise that the best method of preventing further trouble of this sort in the future will be to provide a sewerage system.

The Board would advise that a general system of sewerage for the town be planned first, and that the sewers that may be required be constructed in accordance with this plan as may be necessary from time to time.

RUTLAND (INDUSTRIAL CAMP FOR PRISONERS).

JULY 21, 1904.

To the Board of Prison Commissioners, MR. FREDERICK G. PETTIGROVE, *Chairman.*

GENTLEMEN: — The State Board of Health has considered the plan for the disposal of sewage at the temporary industrial camp for prisoners at Rutland, and has caused the locality to be examined by one of its engineers. The Board is informed that this camp will probably be used for a period of about ten years, and that about 125 persons will be connected with the sewerage system.

The plan provides for the collection of the sewage in a sewer 8 inches in diameter, in which it will be conveyed to a tank or reservoir, whence it will be discharged intermittently upon four filter beds, having an aggregate area of about 5,000 square feet, the effluent from which will find its way into the Ware River. A sludge bed is also provided for the disposal of sludge from the settling tank.

In the opinion of the Board, these plans will, if carried out as proposed, provide satisfactorily for the purification of the sewage of the camp at Rutland under the conditions proposed.

SALEM.

MAY 5, 1904.

HON. J. N. PETERSON, *Mayor, Salem, Mass.*

DEAR SIR: — In accordance with the request of Mr. E. W. Bowditch, engineer in charge of Salem sewerage, for information as to the capacity of the proposed trunk sewer of the city of Salem between the junction of Derby and Webb streets and the site of the proposed pumping station in Salem, the Board directs me to inform you that the plans of said sewer on file in this office, which were approved by this Board on Sept. 3, 1903, are, in its opinion, of sufficient capacity for the present and prospective needs both of the city of Salem and the town of Peabody, should it be decided to dispose of the sewage and manufacturing wastes of both places through this proposed sewer.

AUG. 4, 1904.

To the Sewerage Commission of the City of Salem, Mr. REUBEN AREY, *Secretary*.

GENTLEMEN: — The State Board of Health received from you on July 6, 1904, the following application for the approval of plans of a main sewer in Salem, under the provisions of chapter 353 of the Acts of the year 1901: —

> In accordance with the provisions of Chapter 353 of the Acts of 1901, and by order of the Sewerage Commission of the City of Salem, I hereby respectfully petition your honorable Board for its approval of the Trunk Sewer from Derby St. in Salem to the Peabody line as shown upon plan herewith presented, entitled — Salem, Mass., Sewerage plan, showing location of Proposed North River Trunk Sewer, Scale 400 ft. to an inch; and profile sheets 1-2-3-4-5-6 entitled North River Trunk Sewer, Scales; horizontal 40 ft. to an inch, and vertical, 4 ft. to an inch; both plan and profiles date June 1904 and signed Ernest W. Bowditch, Chief Engineer.

Upon receipt of the application and plans, the Board gave notice of a hearing to be held at its office on July 21, 1904, by publication of the notice in three newspapers published in the city of Salem; and representatives of the city of Salem and the town of Peabody were present at the hearing.

The plans of the proposed sewer as modified and finally presented to the Board provide for a main sewer from the boundary line between the city of Salem and the town of Peabody at Harmony Grove Street, extending through the North River valley in Harmony Grove, Grove, Goodhue, Bridge and Webb streets, and along the south-westerly shore of Collins Cove to the head of the proposed main trunk sewer, which is to extend from Derby Street to the proposed pumping station near Cat Cove; the plan now submittted being a part of the system of sewage disposal for Salem and Peabody approved by the State Board of Health on Sept. 3, 1903, which is designed to dispose of all of the sewage of the city of Salem and the town of Peabody by discharging it into Salem harbor, at an outlet near Great Haste Island. The plan now submitted supersedes, however, that portion of the plan approved last year providing for a sewer from the junction of Pleasant and Webster streets in Salem to the head of the main trunk sewer in Derby Street, a change having been found desirable in the location of a part of this sewer.

The main sewer as now proposed from the boundary line between Salem and Peabody to Derby Street in Salem is of approximately the same capacity as that proposed by the State Board of Health, after an investigation of the requirements of Salem and Peabody in the matter of sewerage in the year 1896, though the upper end of the sewer is at a somewhat lower level than in the plan then proposed.

The State Board of Health, acting under the provisions of chapter 353 of the Acts of the year 1901, having given a hearing in accordance with the requirements of that act, hereby approves the plan and profile of the proposed trunk sewer as now submitted, which provide for a sewer as follows: beginning at Harmony Grove Street, at the boundary line between Salem and Peabody, with a diameter of 52 inches and an elevation of 7.61 feet above mean low water; thence running through Harmony Grove and Grove streets to the North River, at a grade of 1 in 1,500; crossing the North River by means of two lines of pipe, 36 inches in diameter, laid beneath the bottom of the river; thence through Grove to Goodhue Street, with a diameter of 52 inches and a grade of 1 in 1,500; thence through Goodhue and Bridge streets to North Street, with a diameter of 57 inches and a grade of 1 in 2,000; thence through Bridge Street, Webb Street and private land along the shore of Collins Cove to Derby Street, with a diameter of 60 inches and a grade of 1 in 2,000, the sewer at Derby Street being .67 of a foot above mean low water.

The plans bear the following titles: —

Plan: "Salem, Mass., sewerage. Plan showing location of proposed North River trunk sewer. Scale 400 feet to an inch. June 1904. Ernest W. Bowditch, Chief Engineer."

Profile: "Salem, Mass., sewerage. North River trunk sewer profile. Scales: Horizontal, 40 feet to an inch. Vertical, 4 feet to an inch. June 1904. Ernest W. Bowditch, Chief Engineer." (6 sheets, Nos. 1–6.)

The Board hereby certifies that the capacity of the main trunk sewer, as provided in the plans herein approved, is sufficient to discharge the sewage of the town of Peabody in addition to that naturally tributary to this sewer in the city of Salem, including such manufacturing wastes from both places as may reasonably be disposed of through this sewer.

SOUTHBOROUGH (DEERFOOT FARM COMPANY).

MAY 5, 1904.

To the Deerfoot Farm Company, Southborough, Mass., MR. ROBERT M. BURNETT, *Treasurer.*

GENTLEMEN: — The State Board of Health has considered your proposed plans for the disposal and purification of the wastes of the works of the Deerfoot Farm Company at Southborough, designed to purify 25,000 gallons of washings from the dairy and slaughter house of the works, and has caused the locality to be examined by its engineer.

It appears, from information submitted by you, that the quantity of waste amounts to from 20,000 to 25,000 gallons per day in the winter season, and to less than 20,000 gallons per day in the summer; and that the wastes in the summer season are composed almost wholly of waste from the creamery, containing more or less milk, while in winter the creamery waste is somewhat less than in summer; but, in addition to the creamery waste, there is a considerable quantity of waste from the slaughter house. It further appears that the creamery wastes consist of water used for washing purposes, and a little milk; but the Board is informed that most of the skimmed milk is now removed and discharged into the ground at some place where it is not objectionable. The wastes from the slaughter house consist chiefly of water used for washing.

The present method of disposal of the wastes is to discharge them upon fourteen small sand filter beds near the New York, New Haven & Hartford Railroad, north-west of the buildings. These beds appear to be well adapted for the purification of these wastes, and the purification appears to be satisfactory, but an objectionable odor is noticeable in the neighborhood of the beds.

The plan now proposed for the purification of these wastes provides for three settling tanks, a charcoal filter and a coke sludge filter to receive the solid matter which may accumulate in the tanks. The entire plant is to be enclosed within a building, which will include a compost table, where the material collected on the sludge filter will be mixed with coke or coal dust and burned beneath the boilers. The plans provide for three settling tanks, having a total capacity of 5,400 gallons; and, with all three tanks in use and the flow of sewage amounting to 25,000 gallons per day for ten hours, the sewage will be about two hours in passing through the settling tanks. These tanks are so arranged that one can be separated from the others while it is being cleaned.

From the settling tanks the sewage passes to a charcoal filter, and a flush tank is indicated on the plans, with the intention, apparently, of discharging sewage intermittently; but the details of the operation of this settling tank or of the method of applying sewage to the charcoal filters are not shown. The charcoal filter, as indicated on the plans, has an area of 21 square feet. With a flow of 25,000 gallons per day, the rate of filtration through this filter would be about 50,000,000 gallons per acre per day. The sludge filter indicated on the plans has an area of 42 square feet. Each of the tanks has a capacity of 240 cubic feet, and the whole contents of a tank would apparently be discharged upon the sludge filter each time it is emptied. This would be sufficient to flood the sludge filter to a depth of nearly 5 feet. The effluents from the sludge and charcoal filters are to be discharged upon the present sand filters.

In the opinion of the Board, the plan for purifying the wastes from your creamery in the manner indicated would be entirely inadequate for the purpose, and the Board does not advise its adoption.

On several occasions, when the present filters have been examined, it has been found that the sewage has been allowed to flow for long periods upon a small portion of the area. It appears to the Board probable that by applying the sewage to these beds properly they will purify the wastes in a satisfactory manner. The flow of sewage should be changed from bed to bed in rotation, and an amount applied that shall make a depth not greater than 2 inches at any one time. The Board would advise that this method of operation be followed, and the results observed; and if the results should not then be satisfactory, the Board will, upon application, give you further advice as to the disposal of these wastes.

South Hadley.

April 28, 1904.

To the Committee on Sewers, South Hadley Falls, Mass., Mr. M. J. Moriarty, *Chairman.*

Gentlemen: — The State Board of Health received from you on April 11, 1904, a communication giving notice of your intention to use the stream known as Buttery Brook, which flows through the village of South Hadley, as a place of disposal for the sewage of the village, and requesting the advice of the Board thereon; and in response to this communication the Board has caused the locality to be examined by one of its engineers. The results of this examination show that at the present time one of the tributaries of Buttery Brook is greatly polluted by sewage from about 60 dwelling houses, and that below this tributary the main brook passes through the school grounds, where it receives additional sewage from about 700 pupils discharged through two outlets, one discharging directly into the brook, while the other discharges upon the ground a short distance from the bank. The stream and its surroundings in the densely populated part of the village are at present extremely foul and offensive.

The plan proposed as a remedy for the existing conditions provides for cleaning out and straightening the channel of the brook, which is now very crooked, and much obstructed by débris of various kinds, and thereafter using this channel as a main sewer for this neighborhood.

In the opinion of the Board, this plan is an extremely objectionable one, since the flow of the stream would be so small in the summer season that the proposed channel would be simply an open sewer; and the plan is not only objectionable from a sanitary point of view, but would, in the opinion of the Board, be a more expensive one for the disposal of the sewage of this neighborhood than a plan which would provide for the removal of the sewage in a properly constructed sewer to a suitable outlet into the Connecticut River.

Some of the outlets of sewers already constructed in the village are very serious nuisances and should be abolished. The most economical and satisfactory method of removing the very objectionable conditions now existing in the village of South Hadley will be to prepare first some general plan of sewerage which will provide for all of the thickly settled parts of the village. The sewers required for immediate use can then be constructed in such a way as to form part of this general system, which can be extended from time to time, as may be required. The plan should be made under the direction of an engineer of experience in matters relating to sewerage and sewage disposal; and when the plan has been prepared, the Board will, upon application, give you further advice relative to the sewerage of the town.

WAKEFIELD.

JUNE 15, 1904.

To the Board of Sewer Commissioners of the Town of Wakefield, MR. WM. B. DANIEL, *Secretary*.

GENTLEMEN: — The State Board of Health received from you on May 14, 1904, the following application for the approval of a proposed sewer in Richardson Street, being an extension of the system already approved by this Board: —

> The town of Wakefield, through its sewer commissioners, requests the approval by your Board of the accompanying plan and profile of a proposed sewer in Richardson Street; said sewer will be an extension of the system which has been approved by your Board.

A sewer in Richardson Street was shown on the plan of sewerage approved by this Board in February, 1901, after a hearing, and the plan now presented is a slight modification of the plan presented at that time.

The Board hereby approves the plan of the proposed sewer in Richardson Street as now submitted.

WEST SPRINGFIELD.

MARCH 3, 1904.

To the Board of Selectmen of the Town of West Springfield.

GENTLEMEN: — The State Board of Health received from you on Feb. 10, 1904, an application for advice with reference to a proposed sewer for the removal of sewage and storm water from a district in the northerly part of West Springfield, in which your proposed plan is described as follows: —

> The sewer is to provide for sewage and storm water from the cemetery on Riverdale Street, north of Ashley Avenue, to a point near the north side of Bagg Brook; also from the Country Club northerly to the same point, north of Bagg Brook; thence across private land to the Connecticut River, emptying into the same at the mouth of Bagg Brook. The outlet consists of a small submerged pipe with an overflow outlet, the submerged pipe passing out about fifty (50) feet into the river and the end turned upward and down stream at an angle of about forty-five (45) degrees.

The application is accompanied by a plan of the proposed sewer and outlet. The sewer is about a mile in length in Riverdale Street, and is designed to receive the sewage from houses along the street and to remove the storm water collected upon the street to an outlet into the Connecticut River, so arranged that at times of storm the mingled sewage and storm water will discharge near the bank of the river, while the ordinary flow of sewage will be conveyed to an outlet located 50 feet from the river bank at low water.

The area from which storm water is likely to be discharged into the proposed sewer is not indicated, and the Board is unable to advise you as to whether the capacity is sufficient for the removal of storm water from the area which this sewer is designed to serve.

If the outlet is arranged as proposed so that the dry-weather flow of sewage will be discharged into the river 50 feet from the shore at low water, allowing a part of the flow at times of storm to discharge at the proposed overflow near the river bank, the disposal of the sewage is not likely to cause objectionable conditions in the neighborhood. The Board would advise that the possible need of separating the sewage from the storm water in this district at some future time be taken into consideration in the construction of sewers and house connections.

Pollution of Ponds, Streams and Other Bodies of Water.

The following is the substance of the action of the Board during 1904 in reply to applications for advice relative to the pollution of ponds, streams and other bodies of water: —

Canton (Neponset Woolen Mills).

Feb. 4, 1904.

To the Neponset Woolen Mills, Canton Junction, Mass.

Gentlemen: — In a communication dated Oct. 2, 1903, stating that you had received notice to discontinue the pollution of the Neponset River, you make the following statement: —

> The water diverted from that river by us for power and manufacturing processes is carried through a separate channel for three-quarters of a mile before being put into the river again. This channel is as broad as the river bed, and efficiently cleanses the water from everything objectionable before joining the Neponset River.

After receiving this communication, the Board caused examinations of your factory and the processes carried on therein to be made by one of its engineers, and samples of the wastes from the various processes carried on in the factory and from the canal, both above and below your factory and just above the point where it joins the Neponset River, to be collected for analysis. The results of these examinations and analyses show that all of the sewage of 90 operatives is discharged directly into the canal; that dust from shoddy picking machines is blown into the stream by a fan blast, and is to be seen at nearly all times floating on the surface of the water; and that polluted water which has been used in the washing and dyeing of cloth is discharged into the stream.

The results of the analyses show that the quantity of organic matter present in the water of the channel immediately below your mill is much greater than above, and that the water at the lower end of the channel where it joins the Neponset River is more polluted than the water above your mill. The examinations show clearly that the Neponset River is being polluted by sewage and manufacturing waste from your mill.

LEICESTER.

APRIL 7, 1904.

To the Selectmen and Overseers of the Poor, Leicester, Mass.

GENTLEMEN: — You are hereby notified that the results of examinations made by this Board of the effluent from the sewage filters of the Leicester Poor Farm show that imperfectly purified sewage finds its way from these filters into the water supply of the city of Worcester, and that the disposal of the sewage of the Poor Farm, in the manner in which it is being carried on, is a serious menace to the health of the people of that city, and contrary to the provisions of chapter 75 of the Revised Laws of Massachusetts.

The filters now in use evidently fail to properly purify the sewage. If all of the effluent from the present filters should be collected and applied to other filters properly constructed and operated, it is probable that the efficient purification of the sewage could be effected at all times. It may also be practicable to purify this sewage efficiently by pumping it to the gravelly lands north-east of the Poor Farm, and disposing of it on filters located at a place where the sewage would percolate for a sufficient distance through the ground to become thoroughly purified before entering the water course.

NEW BEDFORD.

JULY 21, 1904.

To the Board of Health of the City of New Bedford.

GENTLEMEN: — In response to your application for advice as to the taking of quahaugs from the bed of the Acushnet River, to be sold as food, the State Board of Health has examined the conditions prevailing about the city of New Bedford and the places from which shellfish are collected, and has made numerous bacterial examinations of shellfish collected from the flats and tidal waters about the city.

This matter was first brought to the attention of the Board about three years ago, and since that time the Board has made investigations as to the effect of the discharge of sewage into flats and tidal waters upon the shellfish contained therein, and also as to the means for determining whether shellfish are injuriously affected by such pollution, and whether they are liable to injure the health of those who may use them as food, either raw or cooked.

The results of these investigations show that shellfish taken from waters polluted by sewage contain the bacteria found in sewage, and are liable to injure the health of those who may use them as food.

The sewage from about two-thirds of the city of New Bedford is discharged directly into New Bedford harbor through twenty-six sewer outlets, and the sewage from the remaining part of the city is discharged into Clark's Cove through about six outlets. The great bulk of the shellfish collected at New Bedford are taken from New Bedford harbor, and observations by the Board show that a large proportion of them are collected on the New Bedford side of the river, often within 400 feet of the shore. Samples of quahaugs, collected from all over the harbor by those who make it a business to collect them for sale, have been analyzed by the Board, and a large proportion have been found to show the presence of sewage bacteria.

In Clark's Cove the observations show that quahaugs are taken all about the upper end of the cove, and examinations of samples of quahaugs taken at different times from this locality by those who make a business of collecting these shellfish for sale have shown that a large percentage of them contain sewage bacteria, evidently derived from the sewage discharged into the cove.

Under the circumstances the Board is of the opinion that shellfish taken from New Bedford harbor and from Clark's Cove are liable to injure the health of those who may use them, and that the further taking of shellfish from these waters under present conditions should be prevented. The Board has therefore brought the matter to the attention of the Commissioners on Inland Fisheries and Game, and has requested the commission to prohibit the taking of shellfish from the waters of New Bedford harbor north of or inside of a line drawn from Fort Point in Fairhaven to a point on the easterly shore of Clark's Point, one mile south of the most southerly sewer outlet in the city of New Bedford, or from the waters of Clark's Cove at any place within three-quarters of a mile of the outlet of any sewer of the city of New Bedford discharging into Clark's Cove.

Plymouth.

March 3, 1904.

To the Board of Health of the Town of Plymouth, J. Holbrook Shaw, M.D., *Chairman*.

Gentlemen: — The State Board of Health has considered your communication, received October 24, relative to the pollution of the water of Eel River in Plymouth by waste products from a rubber factory, in which you request the Board to make an examination of the pollution of the river by these wastes; and in accordance with this request the Board caused the locality to be examined by one of its engineers and a sample of the water of the river to be analyzed.

As a result of the examination, it appeared that a considerable quantity of acid was used in the factory, and that wastes containing organic matter from the processes employed were discharged into the stream. These wastes did not, however, have a very noticeable effect upon the stream at the time this examination was made, and a chemical analysis of a sample of water collected from the river below the works did not show that the water was being seriously polluted. It is possible that the quantity of wastes discharged may be greater at other times, or that in dry weather, when the flow of the stream is small, the stream or its banks may be affected by these waste matters to such an extent as to cause complaint on account of an objectionable appearance or odor.

It is understood that you desire a report at the present time, and the Board presents such information as it has thus far obtained in this matter. The Board will, if you so request, make a further examination of the stream during the coming summer, if its condition again becomes objectionable.

QUINCY.

JUNE 2, 1904.

To the Board of Health of the City of Quincy, DR. THOMAS J. DION, *Secretary*.

GENTLEMEN: — In response to your request of May 16 for an examination of the condition of Furnace Brook, and advice as to the removal of the objectionable conditions in a portion of this valley, the Board has caused the locality to be examined by one of its engineers.

It appears that the objectionable conditions now complained of are the pollution of the brook and the flooding of cellars in a portion of the valley of this brook, especially in the neighborhood of Cross Street and Furnace Avenue. The waters of the brook have evidently risen higher than usual recently, on account of the caving in of a wall a short distance down stream from this district at a time of exceptionally heavy rain; and the cause of the objectionable conditions existing recently has been in part removed by the removal of this obstruction from the brook. The conditions could, however, be greatly improved by preventing the pollution of the brook in this region, and by lowering its bed and straightening its course.

The Board would suggest that it has been found of advantage by many cities, after reaching the size of Quincy, to take and control the brooks and other main lines of drainage, and to maintain them in such condition as to provide for the ready removal of surface water, and prevent their pollution.

SWAMPSCOTT.

OCT. 6, 1904.

To the Metropolitan Park Commission, 14 Beacon Street, Boston, Mass.

GENTLEMEN: — Your communication of September 26 is received, calling attention to an objectionable condition existing at several of the coves along the north shore, especially at King's Beach in Swampscott, where you state that considerable quantities of seaweed have come in, which have been removed by your commission, but that complaints have been received since it was removed that the odors still persist. A communication to your board is also submitted, alleging the pollution of the beach by the discharge of the sewage of Swampscott at Dread Ledge as the cause of the objectionable condition complained of.

The Board has caused an examination of the locality to be made, and finds that at the present time there is a very large deposit of a fibrous plant or seaweed upon the northerly part of King's Beach, north of the outlet of Stacey's Brook. This deposit is greatest at the present time at about high-water level, where the depth of the material is about 6 inches for a width of 10 feet or more; but there is a large quantity above the present level of high tides, evidently deposited there at the time of the previous high course of tides; and the entire width of the beach between high and low water is nearly covered with a layer of this matter, from 1 inch to 2 inches in depth, and a considerable quantity was seen in the water off the shore. The portions above high tide were evidently decomposing, and in places were covered with great numbers of small worms or maggots. The odor of the organic matter deposited between high and low water was not objectionable, resembling the odor of certain shellfish; but the decaying material above the level of high water had an offensive odor. The odor from this material has been less objectionable during the recent cool weather, judging from the information available to the Board, than it is in hot weather; and, at the time the examination was made, the most noticeably objectionable odors were those coming from the carcasses of three dead animals, the largest weighing perhaps 50 pounds.

The organism which has come up on the beach in such great quantities recently evidently grows off the shore, and becomes detached in greater quantities in some seasons than in others.

It is entirely improbable, in the opinion of the Board, that the discharge of the sewage of Swampscott at Dread Ledge has anything to do with the growth of this organism; and there is no evidence whatever that any sewage from that outlet comes upon this beach, the only sewage reaching there being a very small quantity which finds its way into Stacey's Brook in Lynn and Swampscott.

Similar objectionable conditions caused by seaweeds of various kinds have been produced at other places, but the troubles usually have been serious only at infrequent intervals.

The objectionable conditions now complained of could probably be greatly relieved by the removal of the material deposited on the beach by spring tides and tides higher than the average.

WELLESLEY.

SEPT. 14, 1904.

To the Board of Health of the Town of Wellesley, MR. J. ALLEN TAILBY, *Secretary.*

GENTLEMEN: — In response to your request of August 1 for an examination of the water of Lake Waban in Wellesley, relative to its pollution by wastes from a paint mill, and advice as to the conditions found there, the

Board has caused the locality to be examined and samples of the water of the lake to be analyzed. From this examination it appears that tanks have been put in at the mill, into which the portion of the wastes resulting from the manufacture of green paint is discharged, and in this way a considerable quantity of lead formerly wasted into the pond recovered; but only about one-third of the wastes are discharged into these tanks, the remainder still being allowed to flow into the brook and thence into Lake Waban.

The results of the analyses of the water of the lake show that the quantity of lead present is about the same as at the time the previous examination was made, showing no improvement as yet since the tanks were introduced.

The information furnished to the Board as to the operation of the present tanks indicates that much lead can be removed from the wastes by passing them through tanks, and much valuable material secured; but it is essential, in order to secure the best results from this treatment, to provide sufficient tank capacity for the treatment of all of the wastes which are polluting the lake, instead of treating only a portion of them, as at present.

WINCHESTER.

OCT. 18, 1904.

To the Board of Health of the Town of Winchester, MR. JAMES HINDS, *Secretary*.

GENTLEMEN: — The State Board of Health received from you on Sept. 14, 1904, a communication requesting the Board to take some action relative to a nuisance caused by Russel Brook in Winchester, in which you state: —

> We desire hereby to formally complain to the State Board of Health of the dangerous nuisance existing in Winchester, caused by the pollution of Russel Brook by sundry parties in Woburn allowing their sewage, consisting of decomposing fleshings and vat refuse, the odor from which is beyond description, to therein drain. Complaints from people abutting on the brook have been numerous and justifiable to this board, that the conditions resulting are unbearable, and a direct menace, in the opinion of this board, to their health and that of the entire community.

In response to your request, the Board has caused the locality to be examined by its engineer and samples of the water of the stream collected at several points in Woburn and Winchester to be analyzed.

The results of the examinations show that the brook receives foul wastes from the Robertson tannery on Eastern Avenue, that other polluting matters are evidently discharged into it by tanneries located between Prospect Street and John Street in Woburn, and that the stream where it enters Winchester was badly polluted and had a very foul odor at the time this examination was made, on September 27.

The liquid wastes from the various tanneries which now pollute the stream can be kept out of the stream and disposed of by discharging them into the sewers, which were designed for the removal of these wastes as well as for the domestic sewage of this region.

In the opinion of the State Board of Health, the nuisance of which you complain can be prevented by action of the Woburn board of health under existing laws, and the attention of that board has been called to the results of the investigation of September 27.

WOBURN.

Oct. 18, 1904.

To the Board of Health of the City of Woburn.

GENTLEMEN: — Complaint having been made to the State Board of Health of a nuisance existing in Winchester near the boundary line between Winchester and Woburn, caused by the pollution of Russel Brook, the Board has caused the stream to be examined and samples of its waters to be analyzed.

The results of the analyses show that the water is very badly polluted, and when examined the odor in the neighborhood of the brook near the place where it crosses the boundary between Woburn and Winchester was very offensive. An examination shows that wastes from the Robertson tannery, so called, on Eastern Avenue in Woburn, and wastes from tanneries located between Prospect Street and John Street, in Woburn, find their way into the stream; and the offensive conditions complained of are evidently caused chiefly by the pollution of the stream by these wastes.

In the opinion of the State Board of Health, your Board has power under the existing laws to prevent the nuisance now existing, as a result of the discharge of tannery wastes into Russel Brook; and the Board brings the matter to your attention, in order that you may take such action as may be necessary.

The liquid wastes from the Robertson tannery can be disposed of into the existing sewerage system by extending the sewers; and the wastes from the remaining tanneries which now pollute Russel Brook can be collected and discharged into the sewers which pass through or near these works. Some preliminary treatment of the wastes will probably be required, to prevent the entrance into the sewers of matters which might interfere with their operation.

WORCESTER.

Oct. 6, 1904.

To Messrs. EDWIN P. CRERIE, ALBERT E. NEEDHAM, WILLIAM F. ROSS and Others,
Residents of Lake View, Worcester.

GENTLEMEN: — The State Board of Health has considered your petition of Sept. 17, 1904, requesting that steps be taken whereby the sewage of the insane hospital on Belmont Street, Worcester, may be disposed of without discharging it into Lake Quinsigamond, and has caused the locality to be examined by one of its engineers. It appears from this examination that the sewage of the Worcester Insane Hospital is discharged upon the lands east of the hospital, where a portion of it is used for the irrigation of crops and the remainder allowed to flow into pits or collect in pools, whence a portion of it evidently overflows at times of rain into Lake Quinsigamond, as stated in your petition.

The present method of disposing of the sewage creates a serious nuisance, besides polluting the lake. The examinations of the Board indicate that it is practicable to dispose of this sewage in a satisfactory manner, and prevent the objectionable conditions that now exist; and the Board will bring the matter to the attention of the hospital authorities.

Worcester (Worcester Insane Hospital).

Oct. 6, 1904.

To the Trustees of the Worcester Insane Hospital, Worcester, Mass.

Gentlemen: — The attention of the State Board of Health has been called to the discharge of sewage from the hospital into Lake Quinsigamond, and upon examination the Board finds that the sewage of the institution is used in part for the irrigation of crops, and that a large portion of it is discharged into pits or pools, where it accumulates to a depth of several feet, putrefies, and gives off a very offensive odor, creating a serious nuisance in the neighborhood, besides causing the pollution of the lake by the overflow from these pits.

The soil within the grounds of the hospital in this region appears to be coarse and porous, and well adapted to the purification of sewage by intermittent filtration; and there is very little doubt that filter beds could be constructed upon the hospital grounds at a reasonable expense, which would purify satisfactorily all of the sewage of the hospital and prevent the existing nuisance and the further pollution of the lake.

The Board would advise that you cause an investigation to be made, to determine the best practicable location for filter beds, and that plans be prepared for a sufficient area of filters to purify efficiently all of the sewage of the institution. It is advisable, in making the investigations and preparing plans, that you secure the assistance of an engineer of experience in matters relating to sewage disposal.

When investigations have been made and plans prepared, the Board will, upon application, give you further advice as to the disposal of the sewage.

EXAMINATION OF PUBLIC WATER SUPPLIES.

EXAMINATION OF PUBLIC WATER SUPPLIES.

The examination of public water supplies in Massachusetts was begun in the year 1887, under the provisions of chapter 274 of the Acts of the year 1886, entitled "An Act to protect the Purity of Inland Waters," and has been carried on to the present time under the provisions of that and subsequent laws. Each of the sources of water supply in the State has been examined from time to time to note changes in its physical condition, and chemical analyses of the waters of the various sources have been made, usually about once a month, supplemented by biological examinations of the waters of surface sources, and occasionally by determinations of the number of bacteria in both the surface and ground water sources. Information has been collected also as to temperature, rainfall, flow of streams, and such other matters as might affect the quality of the waters of the various sources. The work has been carried on under the direction of the chief engineer of the Board, the chemical and biological examinations being made at the laboratory for water analysis by the chemist of the Board.

The results of the earlier of these examinations were published in a special report of the Board on the examination of water supplies in 1890, and results of examinations made in subsequent years have been published in the annual reports. In the present report the results of the chemical analyses of the various sources are presented in tables and summaries so arranged as to afford a means of comparing the various waters with respect to color, organic matter, hardness, and the other properties usually considered in determining the quality of a water used for drinking; and a summary of the population within the watershed of each surface-water source is also presented. In order to show more nearly the average character of the various waters, the average of all of the analyses of the past five years has been used in making the tables.

At the end of the year 1904 all of the 33 cities in Massachusetts and 147 of the 320 towns were provided with public water supplies. This list includes all the places in the State having, according to the census of 1900, a population in excess of 6,000; and there are only 9 towns in the State which have a population in excess of 3,000 which are not provided with public water supplies. The total population, according to the census of 1900, of the cities and towns provided with public water supplies is 2,590,037, while the population of those towns not having water supplies is 215,309.

While there are considerable areas in nearly all of the cities and towns in which the public water supply is not available, these areas are sparsely populated; and the number of people to whom the public water supply is not available in cities and towns having public water supplies is small. In addition to the cities and towns having public water supplies, there are cases in which a portion of the inhabitants of a town or village are supplied with water from some common source, generally a spring or well upon a neighboring hillside, the water of which is delivered in the houses through very small pipes, and a few towns in which the number of inhabitants supplied from such sources forms a large proportion of the whole population have been included in the list of cities and towns having public water supplies, though the analyses of the waters supplied to these places are omitted. There are also cases in which owners of factories and mills have private water supplies, used chiefly for protection against fire, but also to supply water for domestic purposes to buildings and tenements in the neighborhood, and those towns in which the population supplied in this way forms an important part of the whole have been included also.

Outside the areas provided with public water supplies and the places supplied with water from mills, etc., the sources of water supply of the inhabitants of the State are chiefly wells, located in the immediate neighborhood of the owner's dwelling. In many of the cities and larger towns spring waters are sold for drinking purposes, in packages of generally from one to five gallons. The spring-water sources were examined by the Board in 1900, and for the results of this examination reference is made to the report of that year.

The following table gives a list of the cities and towns having public water supplies which are available in the whole or in an important part of their territories, with the population of each, the date of introduction of works, the ownership of the works, and the source or sources of water supply at the present time: —

TABLE NO. 1.

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
Metropolitan Water District.*	830,709	–	– –	Wachusett Reservoir on south branch of Nashua River, Clinton. Framingham Reservoir No. 2 on Sudbury River, Framingham. Reservoirs on tributaries of Sudbury River, as follows: Sudbury Reservoir on Stony Brook, Southborough, which receives water from Wachusett Reservoir; Framingham Reservoir No. 3 on Stony Brook, Framingham, which receives water from Sudbury Reservoir; Hopkinton Reservoir on Indian Brook, Hopkinton; Ashland Reservoir on Cold Spring Brook, Ashland. Lake Cochituate, Wayland and Natick.
Arlington,	8,603	1872	Town,	
Belmont,	3,929	1887	Town,	
Boston,	560,892	1848	City,	
Chelsea,	34,072	1867	City,	
Everett,	24,336	1867	City,	
Lexington,	3,831	1884	Town,	
Malden,	33,664	1870	City,	
Medford,	18,244	1870	City,	
Melrose,	12,962	1870	City,	
Milton,	6,578	1885	Town,	
Nahant,	1,152	1885	Town,	
Quincy,	23,899	1884	City,	
Revere,	10,395	1884	Private,†	
Somerville,	61,643	1867	City,	
Stoneham,	6,197	1883	Town,	
Swampscott,	4,548	1885	Town,	
Watertown,	9,706	1885	Town,	
Winthrop,	6,058	1884	Private,‡	
Abington,	4,489	1887	Town,	Big Sandy Pond, Pembroke.
Rockland,	5,327	1887	Town,	
Adams,	11,134	1874	Fire district,	Bassett Brook; Dry Brook, Cheshire; tubular wells near Hoosick River, Cheshire.
Agawam,	2,536	1877	Private,	Springs.
Amesbury,	9,473	1885	Private,‡	Two systems tubular wells.
Amherst,	5,028	1880	Private,	Amethyst Brook, Pelham, on which there is a storage reservoir; spring in Pelham.
Andover,	6,813	1890	Town,	Haggett's Pond.
Arlington,	–	–	– –	See Metropolitan Water District.
Ashburnham,	1,882	1870	Town,	Storage reservoir.
Ashfield,	955	1904	Private,	Bear Swamp Brook.
Athol,	7,061	1875	Private,†	Storage reservoir in Phillipston; storage reservoir on Buckman Brook.
Attleborough,	11,335	1873	Town,	Large well near Seven Mile River.
Avon,	1,741	1890	Town,	Large well.
Ayer,	2,446	1887	Town,	Large well.
Barre,	2,059	1895	Private,	Storage reservoir.
Belmont,	–	–	– –	See Metropolitan Water District.

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* This district was established by act of the Legislature in 1895. The dates of introduction of water in the cities and towns of the district are the dates of completion of the earlier works.

† Works of water company taken by town early in 1905. ‡ Town has voted to take works (1905).

TABLE No. 1 — *Continued.*

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
Beverly,	–	–	– –	See Salem.
Billerica,	2,775	1898	Town,	Tubular wells near Concord River.
Boston,	–	–	– –	See Metropolitan Water District.
Braintree,	5,981	1887	Town,	Filter-gallery and tubular wells near Little Pond; Great Pond (used also by Randolph and Holbrook).
Bridgewater,	5,806	1888	Private,	Tubular wells and large wells near Town River.
East Bridgewater,	3,025	1888	Private,	
Brockton,	40,063	1880	City,	Silver Lake, Pembroke; storage reservoir on Salisbury Brook.
Whitman,	6,155	1883	Town,	
Brookfield,	3,062	1889	Town,	Storage reservoir; Seven Mile River.
Brookline,	19,935	1875	Town,	Tubular wells and filter-gallery near Charles River.
Cambridge,	91,886	1856	City,	Storage reservoir on Stony Brook, Waltham and Weston; storage reservoirs on Hobbs Brook, Waltham, Lincoln and Lexington; Fresh Pond.
Canton,	4,584	1889	Town,	Large well and tubular wells at Springdale; large well at Henry's Spring, Stoughton.
Chelsea,	–	–	– –	See Metropolitan Water District.
Cheshire,	1,221	1876	Private,	Thunder Brook; Kitchen Brook.
Chester,	1,450	1893	Fire district,	Austin Brook.
Chicopee,	19,167	1845	City,	Morton Brook; Cooley Brook; Dingle Brook Reservoir.
Clinton,	13,667	1882	Town,	Lynde's Pond, Sterling; Spring Basin, Sterling; Heywood Brook, Sterling.
Lancaster,	2,478	1885	Town,	
Cohasset,	2,759	1886	Private,	Two systems tubular wells; filter-gallery near Lily Pond.
Colrain,	1,749	1902	Fire district,	Mountain Brook.
Concord,	5,652	1873	Town,	Sandy Pond, Lincoln.
Lincoln,	1,127	1874	Town,	
Cottage City,	1,100	1890	Private,	Springs.
Dalton,	3,014	1884	Fire district,	Storage reservoir on Egypt Brook.
Danvers,	8,542	1876	Town,	Middleton Pond, Middleton.
Middleton,	839	1876	Town,	
Dedham,	7,457	1881	Private,	Large well and tubular wells near Charles River.
Deerfield,	1,969	1903	Water supply district.	Roaring Brook, Whately.
Dracut,	3,253	1900	Private,	Tubular wells near Beaver Brook.
East Bridgewater,	–	–	– –	See Bridgewater.
Easthampton,	5,603	1870	Town,	Bassett Brook.
Easton,	4,837	1887	Village district.	Large well.
Erving,	–	–	– –	See Montague.
Everett,	–	–	– –	See Metropolitan Water District.
Fairhaven,	3,567	1894	Private,	Tubular wells near Nasketucket River.

TABLE No. 1 — *Continued.*

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
Fall River,	104,863	1874	City,	North Watuppa Lake.
Falmouth,	3,500	1899	Town,	Long Pond.
Fitchburg,	31,531	1872	City,	Scott Reservoir; Falulah Reservoir; Meetinghouse Pond, Westminster.
Foxborough,	3,266	1891	Water supply district.	Tubular wells.
Framingham,	11,302	1885	Private,*	Filter-gallery near Farm Pond.
Franklin,	5,017	1884	Private,	Large wells near Mill Brook; Beaver Pond.
Gardner,	10,813	1882	Town,	Crystal Lake.
Gill,	1,015	1888	Private,	Spring.
Gloucester,	26,121	1885	City,	Dike's Brook Reservoir; Haskell Brook Reservoir; Wallace Reservoir.
Grafton,	4,869	1886	Private,	Large well near Quinsigamond River.
Great Barrington,	5,854	1867	Fire district,	East Mountain Reservoir; Green River.
Greenfield,	7,927	1870	Fire district,	Storage reservoir on Glen Brook, Leyden; Green River.
Groton,	2,052	1897	Private,	Large well near Baddacook Pond.
Hardwick,	3,203	–	Private,	Springs.
Hatfield,	1,500	1896	Town,	Storage reservoir on Running Gutter Brook.
Haverhill,	37,175	1802	City,	Crystal Lake; Pentucket Lake; Kenoza Lake; Johnson's Pond; Millvale Reservoir.
Hingham,	5,059	1880	Private,	Accord Pond; large well near Fulling Mill Pond.
Hull,	1,703	1882	Private,	
Hinsdale,	1,485	1889	Fire district,	Storage reservoir.
Holbrook,	–	–	– –	See Randolph.
Holliston,	2,598	1891	Private,	Large well.
Holyoke,	45,712	1873	City,	Manhan River, Southampton; Wright and Ashley Pond; high-service reservoir; Whiting Street Reservoir, Northampton.
Hopedale,	–	–	– –	See Milford.
Hopkinton,	2,623	1884	Town,	Tubular wells.
Hudson,	5,454	1884	Town,	Gates Pond, Berlin.
Hull,	–	–	– –	See Hingham.
Huntington,	1,475	1899	Fire district,	Cold Brook, Blandford.
Hyde Park,	13,244	1885	Private,	Tubular wells near Neponset River; tubular wells near Mother Brook, Dedham.
Ipswich,	4,658	1894	Town,	Storage reservoir on Dow's Brook.
Kingston,	1,955	1886	Town,	Large well near Jones River; tubular wells.
Lancaster,	–	–	– –	See Clinton.
Lawrence,	62,559	1875	City,	Merrimack River, filtered.
Lee,	3,596	1881	Private,	Codding Brook, on which is a storage reservoir; Basin Pond Brook.
Leicester,	3,416	1891	Water supply district.	Large wells.
Lenox,	2,942	1875	Private,	Storage reservoir; Yokun River.

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* Town has voted to take works (1905).

TABLE No. 1 — *Continued.*

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
Leominster, . .	12,392	1873	Town, . .	Haynes Reservoir; Morse Reservoir; Fall Brook Reservoir.
Lexington, . . .	–	–	– –	See Metropolitan Water District.
Lincoln, . . .	–	–	– –	See Concord.
Longmeadow, . .	811	1895	Town, . .	Cooley Brook.
Lowell, . . .	94,969	1872	City, . .	Tubular wells near Merrimack River.
Ludlow, . . .	–	–	– –	See Springfield.
Lynn, ...	68,513	1871	City, . .	Birch Reservoir, Lynn and Saugus; Breed's Reservoir; Walden Reservoir, Lynn and Saugus; Glen Lewis Reservoir; Hawkes Reservoir, Lynn and Saugus; Saugus River, Saugus.
Saugus, . . .	5,084	1878	Town, . .	
Malden, . . .	–	–	– –	See Metropolitan Water District.
Manchester, . .	2,522	1892	Town, . .	Large well and tubular wells near Saw Mill Brook.
Mansfield, . . .	4,006	1888	Water supply district.	Large well near Pecuanticlot River.
Marblehead, . .	7,582	1885	Town, . .	Two large wells.
Marlborough, . .	13,609	1883	City, . .	Lake Williams; storage reservoir on Millham Brook.
Marshfield, . . .	1,810	1890	Private, .	Large well.
Maynard, . . .	3,142	1889	Town, . .	White Pond.
Medfield, . . .	2,926	–	Private, .	Spring.
Medford, . . .	–	–	– –	See Metropolitan Water District.
Melrose, . . .	–	–	– –	See Metropolitan Water District.
Merrimac, . . .	2,131	1904	Town, . .	Tubular wells near Kimball's Pond.
Methuen, . . .	7,512	1875	Town, . .	Tubular wells near Spicket River.
Middleborough, . .	6,885	1885	Fire district,	Large well near Nemasket River.
Middleton, . . .	–	–	– –	See Danvers.
Milford, . . .	11,376	1881	Private, .	Charles River, filtered. Large wells.
Hopedale, . .	2,087	1881	Private, .	
Millbury, . . .	4,460	1895	Private, .	Large well.
Millis, ...	1,053	1891	Town, . .	Spring.
Milton, . . .	–	–	– –	See Metropolitan Water District.
Monson, . . .	3,402	1895	Town, . .	Large well.
Montague, . . .	6,150	1887	Fire district,	Lake Pleasant.
Erving, . . .	973	–	Fire district,	
Nahant, . . .	–	–	– –	See Metropolitan Water District.
Nantucket, . . .	3,006	1878	Private, .	Wannacomet Pond; wells near pond.
Natick, . . .	9,488	1874	Town, . .	Tubular wells near Lake Cochituate.
Needham, . . .	4,016	1890	Town, . .	Large wells; tubular wells.
New Bedford, . .	62,442	1869	City, . .	Great Quittacas Pond, Lakeville; Little Quittacas Pond, Lakeville; storage reservoir on Acushnet River, Acushnet.

TABLE No. 1 — *Continued.*

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
Newburyport,	14,478	1881	City,	Large wells; spring.
Newton,	33,587	1876	City,	Filter-gallery and tubular wells near Charles River, Needham.
North Adams,	24,200	1861	City,	Storage reservoir on Notch Brook; Broad Brook, Pownal, Vt.
Northampton,	18,643	1871	City,	Storage reservoir on Roberts' Meadow Brook; West Brook; Mountain Street Reservoir.
North Andover,	4,243	1898	Town,	Great Pond.
North Attleborough,	7,253	1884	Town,	Large well near Ten Mile River.
Northborough,	2,164	1882	Town,	Storage reservoir on Cold Harbor Brook, Boylston and Shrewsbury.
Northbridge,	7,036	1889	Private,	Storage reservoir on Cook Allen Brook, Sutton; springs.
North Brookfield,	4,587	1893	Town,	Doane Pond; North Pond.
Northfield,	1,966	1900	Private,	Storage reservoir.
Norwood,	5,480	1885	Town,	Buckmaster Pond, Westwood.
Orange,	5,520	1873	Town,	Spring; Coolidge Brook.
Palmer,	7,801	1886	Private,	Storage reservoir.
Peabody,	11,523	1799	Town,	Brown's Pond; Spring Pond, Lynn, Salem and Peabody.
Pittsfield,	21,766	1855	City,	Ashley Lake, Washington; Ashley Brook, Washington; Sacket Brook, Dalton; Hathaway Brook, Dalton; Mill Brook, Washington.
Plymouth,	9,592	1855	Town,	Little South Pond; Great South Pond; Lout Pond.
Provincetown,	4,247	1893	Town,	Large well.
Quincy,	–	–	– –	See Metropolitan Water District.
Randolph,	3,993	1888	Town,	Great Pond, Randolph and Braintree (used also by Braintree).
Holbrook,	2,229	1888	Town,	
Reading,	4,969	1891	Town,	Filter-gallery near Ipswich River.
Revere,	–	–	– –	See Metropolitan Water District.
Rockland,	–	–	– –	See Abington.
Rockport,	4,592	1895	Town,	Cape Pond.
Rutland,	1,334	1896	Town,	Muschopauge Lake.
Salem,	35,956	1868	City,	Wenham Lake, Beverly and Wenham; Longham Reservoir, Beverly and Wenham.
Beverly,	13,884	1868	City,	
Saugus,	–	–	– –	See Lynn.
Scituate,	2,470	1901	Private,	Tubular wells.
Sharon,	2,060	1885	Town,	Large well; tubular wells near Beaver Brook.
Sheffield,	1,804	1897	Private,	Springs.
Shelburne,	1,508	1885	Private,	Springs.
Shirley,	1,680	1903	Town,	Large well.
Somerville,	–	–	– –	See Metropolitan Water District.
Southbridge,	10,025	1880	Private,	Storage reservoir on Hatchet Brook; two reservoirs on small brook.

TABLE NO. 1 — *Continued.*

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
South Hadley, . .	4,526	1872	Fire district,	Storage Reservoir on Buttery Brook; storage reservoir on Leaping Well Brook.
Spencer, . . .	7,627	1883	Town, . .	Shaw Pond, Leicester.
Springfield, . .	62,059	1874	City, . .	Ludlow Reservoir, Ludlow; Jabish Brook, Belchertown; Axe Factory Brook, Belchertown; Broad Brook, Belchertown; Chapin Pond, Ludlow; Higher Brook, Ludlow; Five Mile Pond.
Ludlow, . . .	3,536	1873	Private, .	
Stockbridge, . .	2,081	1862	Private, .	Lake Averic.
Stoneham, . . .	-	-	- -	See Metropolitan Water District.
Stoughton, . . .	5,442	1886	Town, . .	Muddy Brook.
Sunderland, . .	771	-	Private, .	Springs.
Swampscott, . .	-	-	- -	See Metropolitan Water District.
Taunton, . . .	31,036	1876	City, . .	Assawompsett Pond, Lakeville; Elder's Pond, Lakeville.
Tisbury, . . .	1,149	1887	Private,* .	Large well.
Uxbridge, . . .	3,599	1879	Town, . .	Springs.
Wakefield, . . .	9,290	1883	Town, . .	Crystal Lake.
Walpole, . . .	3,572	1896	Town, . .	Tubular wells near Lowe Brook.
Waltham, . . .	23,481	1873	City, . .	Large well near Charles River.
Ware, ...	8,263	1886	Town, . .	Large well and tubular wells near Muddy Brook.
Wareham, . . .	3,432	1894	Private, .	Jonathan's Pond.
Warren, . . .	4,417	1837	Private, .	Springs.
Watertown, . .	-	-	- -	See Metropolitan Water District.
Wayland, . . .	2,303	1878	Town, . .	Storage reservoir on Snake Brook.
Webster, . . .	8,804	1881	Town, . .	Large well and tubular wells near Lake Chaubungagungamaug.
Wellesley, . . .	5,072	1884	Town, . .	Large well; filter-gallery; tubular wells near Rosemary Brook.
Westborough, . .	5,400	1879	Town, . .	Storage reservoir; filter basin.
West Brookfield, .	1,448	1838	Private, .	Springs.
Westfield, . . .	12,310	1874	Town, . .	Moose Meadow Brook, Montgomery, on which is a storage reservoir; Tillotson Brook, Granville.
Weston, . . .	1,834	1896	Private, .	Large well; tubular wells.
West Springfield, .	7,105	1875	Town, . .	Storage reservoir on Darby Brook; large well.
West Stockbridge, .	1,158	-	Private, .	Springs.
Weymouth, . .	11,324	1885	Town, . .	Great Pond.
Whitman, . . .	-	-	- -	See Brockton.
Williamsburg, . .	1,926	1903	Town, . .	Unquomonk Brook.
Williamstown, . .	5,013	1859	Private, .	Cold Spring; Sherman Spring; Paul Brook; Flora Glen Reservoir.
Winchendon, . .	5,001	1896	Town, . .	Large well.
Winchester, . .	7,248	1873	Town, . .	Three storage reservoirs.

* Works of water company taken by town early in 1905.

TABLE No. 1 — *Concluded.*

CITY OR TOWN.	Population in 1900.	Date of Introduction of Water.	Ownership of Works.	Sources of Supply.
Winthrop, . . .	-	-	- -	See Metropolitan Water District.
Woburn, . . .	14,254	1873	City, . .	Filter-gallery near Horn Pond.
Worcester, . . .	118,421	1845	City, . .	Two reservoirs on Tatnuck Brook, Holden; storage reservoir on Lynde Brook, Leicester; four reservoirs on Kettle Brook, Leicester.

In presenting a comparison of the different waters, it is necessary to take into account differences in the physical characteristics of the various sources. The essential differences between surface waters (the waters of lakes, ponds and streams) and ground waters (those derived from wells, filter galleries, springs, etc.) have been described in previous reports, and need only be referred to here. The waters of the two classes differ so greatly in their chemical and biological characteristics that they cannot be judged by the same standards, and in comparing the quality of the waters of the different sources these two classes will be considered separately.

There are also important differences in the physical characteristics of surface-water sources, which affect very materially the quality of their waters. The waters of running streams under normal conditions contain but little organic life; but their waters take up the products of decaying organic matter from the grasses, leaves and soil with which they come in contact, and a greater or less quantity of mineral matter is also dissolved from the soil and rocks over which the waters flow. In ponds and storage reservoirs, on the other hand, vegetable and animal organisms find conditions more favorable to their growth and development, and the amount of such growths and their effect upon the quality of the water differs greatly in different sources. It is of interest to compare, also, the quality of the waters of natural ponds and lakes with that of the waters of artificial reservoirs, and sub-divisions have been made in the tables, so as to facilitate such comparisons.

SURFACE-WATER SUPPLIES.

The averages of all of the analyses of the various surface-water supplies made during the past five years have been calculated, and are presented in the following table.

In this table the analyses of the waters of the metropolitan sources are placed at the beginning, and the others follow in alphabetical order by towns.

In the case of most of the waters the results given in the table are the average of from thirty to sixty analyses, made at regular intervals of one or two months. In a few cases the samples have been collected at longer intervals, but nearly always as often as once in three months, and in a very few cases samples have been collected as often as once in two weeks.

The use of some of the sources included in the table was begun less than five years ago, and the examinations have consequently covered a shorter period than five years. These cases are mentioned in the notes following the table.

TABLE No. 2.—*Averages of Chemical Analyses, from 1900 to 1904, Inclusive.*

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Free.	Albuminoid.			Nitrates.	Nitrites.		
					Total.	Sus-pended.					
Metropolitan Water District.	Nashua River,*	.34	3.63	.0021	.0168	.0025	.23	.0066	.0001	.46	0.9
	Wachusett Reservoir,*	.20	2.86	.0034	.0154	.0031	.22	.0027	.0001	.34	0.9
	Sudbury Reservoir,	.24	3.68	.0032	.0156	.0024	.24	.0090	.0001	.39	1.2
	Framingham Reservoir No. 3.	.22	3.85	.0023	.0156	.0025	.26	.0120	.0001	.38	1.3
	Hopkinton Reservoir,	.51	3.70	.0033	.0210	.0029	.30	.0039	.0000	.67	0.8
	Ashland Reservoir,	.55	3.55	.0021	.0205	.0020	.24	.0026	.0000	.70	0.8
	Framingham Reservoir No. 2.	.69	4.19	.0032	.0226	.0024	.30	.0058	.0000	.80	1.0
	Lake Cochituate,	.22	4.85	.0030	.0208	.0033	.44	.0076	.0002	.44	2.0
	Chestnut Hill Reservoir,	.27	3.87	.0025	.0155	.0020	.26	.0105	.0001	.41	1.3
	Spot Pond,	.07	3.94	.0018	.0153	.0022	.29	.0033	.0000	.27	1.6
	Tap in State House,	.24	4.01	.0015	.0144	.0018	.30	.0119	.0001	.39	1.5
	Tap in Revere,	.11	3.95	.0014	.0143	.0019	.29	.0057	.0001	.30	1.7
	Tap in Quincy,	.23	4.07	.0010	.0134	.0015	.32	.0155	.0001	.38	1.6
Abington,	Big Sandy Pond,	.11	3.22	.0022	.0157	.0018	.62	.0020	.0000	.23	0.5
Adams,	Bassett Brook,	.02	3.72	.0005	.0039	.0006	.07	.0159	.0000	.13	2.5
	Dry Brook,	.17	7.22	.0013	.0090	.0010	.10	.0084	.0001	.32	4.9
Amherst,	Amethyst Brook Reservoir.*	.39	3.36	.0021	.0143	.0015	.13	.0037	.0000	.55	0.4
Andover,	Haggett's Pond,	.13	3.16	.0014	.0152	.0012	.30	.0020	.0000	.31	1.2
Athol,	Phillipston Reservoir,*	.62	3.43	.0049	.0334	.0110	.15	.0042	.0000	.76	0.6
	Buckman Brook Reservoir.*	.38	3.34	.0026	.0212	.0043	.14	.0029	.0000	.61	0.7
Barre,	Reservoir,*	.07	3.65	.0100	.0365	.0070	.11	.0010	.0000	.32	1.2
Brockton,	Salisbury Brook Reservoir.*	.55	3.70	.0019	.0233	.0036	.34	.0014	.0000	.69	0.6
	Silver Lake,	.09	2.95	.0010	.0136	.0018	.61	.0013	.0000	.26	0.4
Cambridge,	Lower Hobbs Brook Reservoir.	.13	4.89	.0029	.0265	.0045	.36	.0035	.0001	.41	2.1
	Stony Brook Reservoir,	.40	5.42	.0030	.0234	.0033	.44	.0138	.0002	.57	2.2
	Fresh Pond,	.18	6.88	.0053	.0227	.0055	.59	.0245	.0004	.36	3.2

* See Notes.

TABLE No. 2.—*Averages of Chemical Analyses, etc.*—Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.						
				Free.	Total.	Sus-pended.		Nitrates.	Nitrites.		
Cheshire, . .	Thunder Brook, . .	.01	4.42	.0009	.0039	.0004	.06	.0085	.0000	.07	3.3
Cheshire, . .	Kitchen Brook, . .	.01	5.01	.0013	.0052	.0022	.06	.0069	.0000	.06	3.6
Chester, . . .	Austin Brook, . .	.07	3.00	.0006	.0055	.0004	.08	.0070	.0001	.20	1.4
Chicopee, . .	Morton Brook, . .	.02	3.46	.0006	.0044	.0008	.12	.0052	.0000	.08	0.7
	Cooley Brook, . .	.59	4.12	.0019	.0139	.0024	.12	.0033	.0000	.61	0.9
Concord, . . .	Sandy Pond, . . .	.02	2.37	.0011	.0131	.0014	.26	.0018	.0000	.17	0.4
Dalton, . . .	Egypt Brook Reservoir,	.25	2.60	.0014	.0110	.0015	.06	.0162	.0000	.48	0.8
Danvers, . . .	Middleton Pond, . .	.54	3.81	.0017	.0193	.0025	.32	.0016	.0000	.73	1.2
Deerfield, . .	Roaring Brook,* . .	.03	5.82	.0009	.0039	.0006	.10	.0080	.0000	.08	3.5
Easthampton, . .	Bassett Brook, . .	.19	3.55	.0011	.0089	.0019	.11	.0048	.0001	.29	1.2
Fall River, . .	North Watuppa Lake, .	.15	3.35	.0013	.0180	.0025	.52	.0018	.0001	.37	0.6
Falmouth, . .	Long Pond, . . .	.00	2.90	.0014	.0099	.0009	.92	.0006	.0000	.08	0.2
Fitchburg, . .	Meetinghouse Pond, .	.06	2.36	.0016	.0136	.0019	.14	.0016	.0000	.25	0.5
	Scott Reservoir, . .	.16	2.47	.0057	.0192	.0056	.15	.0026	.0001	.32	0.3
Gardner, . . .	Crystal Lake, . .	.05	3.76	.0025	.0173	.0028	.30	.0073	.0000	.23	1.3
Gloucester, . .	Dike's Brook Reservoir,	.34	3.78	.0030	.0186	.0032	.85	.0030	.0000	.43	0.3
	Wallace Reservoir, .	.37	4.17	.0037	.0229	.0060	1.04	.0016	.0000	.49	0.4
	Haskell Brook Reservoir.*	.45	4.06	.0053	.0212	.0058	.87	.0010	.0000	.55	0.4
Great Barrington, .	East Mountain Reservoir.	.12	4.56	.0059	.0075	.0020	.10	.0008	.0002	.24	3.0
	Green River, . . .	.01	8.39	.0012	.0031	.0004	.09	.0270	.0000	.06	6.4
Greenfield, . .	Glen Brook Reservoir,	.02	5.10	.0007	.0038	.0002	.12	.0121	.0000	.07	3.3
Hatfield, . . .	Reservoir, . . .	.11	3.88	.0016	.0059	.0007	.12	.0119	.0000	.24	1.7
Haverhill, . .	Johnson's Pond, . .	.10	4.03	.0012	.0166	.0016	.35	.0022	.0000	.32	1.9
	Crystal Lake, . .	.16	3.02	.0013	.0166	.0019	.25	.0019	.0000	.36	0.9
	Kenoza Lake, . .	.09	3.71	.0013	.0149	.0016	.39	.0011	.0000	.25	1.7
	Pentucket Lake, . .	.04	3.61	.0010	.0160	.0019	.38	.0019	.0000	.22	1.6
	Millvale Reservoir, .	.52	4.77	.0017	.0207	.0022	.33	.0029	.0000	.70	1.7
Hingham, . .	Accord Pond, . .	.19	2.90	.0010	.0128	.0013	.58	.0016	.0000	.36	0.3
Hinsdale, . .	Storage reservoir, . .	.20	2.06	.0044	.0210	.0076	.06	.0041	.0000	.34	0.2
Holyoke, . . .	Whiting Street Reservoir.	.08	4.24	.0026	.0237	.0069	.13	.0024	.0001	.25	2.4
	Manhan River, . .	.32	3.67	.0014	.0133	.0022	.11	.0029	.0000	.46	1.4
	Wright and Ashley Pond.	.09	4.20	.0025	.0166	.0032	.13	.0033	.0001	.26	2.1
Hudson, . . .	Gates Pond, . . .	.08	2.53	.0028	.0151	.0019	.20	.0046	.0000	.21	0.6

* See Notes.

TABLE NO. 2. — *Averages of Chemical Analyses, etc.* — Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Free.	Albuminoid. Total.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
Huntington, . .	Cold Brook, . . .	.17	3.17	.0015	.0126	.0015	.10	.0040	.0000	.34	1.0
Ipswich, . . .	Dow's Brook Reservoir,	.24	4.45	.0022	.0196	.0026	.56	.0044	.0001	.42	1.6
Lawrence, . .	Merrimack River, filtered.	.34	4.56	.0124	.0097	.0009	.28	.0255	.0001	.40	1.7
Lee, ...	Upper Reservoir on Codding Brook.	.35	2.79	.0070	.0278	.0069	.11	.0032	.0000	.63	0.4
	Codding Brook, . .	.18	3.56	.0014	.0095	.0008	.08	.0057	.0001	.36	1.7
Lenox, . . .	Reservoir, . . .	.05	8.05	.0015	.0122	.0020	.09	.0048	.0000	.18	5.8
Leominster, . .	Morse Reservoir, . .	.19	2.24	.0032	.0198	.0045	.14	.0024	.0001	.37	0.1
	Haynes Reservoir, . .	.17	2.26	.0047	.0319	.0108	.13	.0021	.0000	.38	0.1
	Fall Brook Reservoir, .	.11	2.17	.0013	.0152	.0028	.14	.0021	.0000	.31	0.2
Longmeadow, .	Cooley Brook, . .	.06	4.50	.0015	.0059	.0016	.17	.0265	.0002	.12	2.4
Lynn, . . .	Birch Reservoir, . .	.34	3.98	.0051	.0245	.0043	.46	.0044	.0001	.50	1.1
	Breed's Reservoir, .	.36	3.51	.0039	.0208	.0034	.47	.0028	.0000	.51	0.8
	Glen Lewis Reservoir, .	.25	3.08	.0062	.0291	.0084	.37	.0019	.0000	.41	0.4
	Walden Reservoir, .	.39	3.50	.0034	.0286	.0066	.39	.0021	.0000	.58	0.7
	Hawkes Reservoir, .	.38	4.37	.0034	.0248	.0034	.48	.0031	.0001	.61	1.4
	Saugus River, . .	.86	7.49	.0050	.0331	.0037	.69	.0051	.0002	1.00	3.2
	Tap, ...	.36	4.10	.0030	.0215	.0027	.45	.0053	.0001	.55	1.2
Marlborough, . .	Lake Williams, . .	.08	4.12	.0022	.0225	.0041	.47	.0038	.0001	.26	1.6
	Millham Brook Reservoir.	.46	3.95	.0054	.0258	.0057	.30	.0071	.0001	.54	1.3
Maynard, . . .	White Pond, . . .	.04	2.67	.0008	.0119	.0019	.31	.0034	.0000	.15	0.6
Milford, . . .	Charles River, filtered,*	.20	3.93	.0018	.0100	–	.28	.0165	.0001	.34	1.1
Montague, . .	Lake Pleasant, . .	.02	2.46	.0018	.0077	.0011	.12	.0040	.0000	.09	0.4
Nantucket, . .	Wannacomet Pond, .	.07	6.78	.0037	.0237	.0091	2.29	.0018	.0000	.15	1.5
Natick, . . .	Dug Pond,* . . .	.13	4.95	.0077	.0187	.0024	.54	.0137	.0001	.27	2.1
New Bedford, . .	Old Storage Reservoir,	1.00	4.77	.0035	.0264	.0041	.53	.0021	.0000	1.01	0.9
	Little Quittacas Pond, .	.25	3.34	.0015	.0169	.0022	.49	.0014	.0000	.45	0.6
	Great Quittacas Pond, .	.43	3.42	.0017	.0180	.0026	.49	.0010	.0000	.62	0.6
	Tap at City Hall, . .	.22	3.32	.0016	.0174	.0019	.49	.0014	.0000	.43	0.7
North Adams, . .	Notch Brook Reservoir,	.03	6.75	.0047	.0101	.0022	.07	.0034	.0002	.14	5.0
	Broad Brook, . . .	.16	3.63	.0019	.0085	.0012	.07	.0179	.0000	.34	1.8
Northampton, . .	Middle Reservoir, . .	.21	3.88	.0013	.0127	.0024	.11	.0033	.0000	.35	1.5
	West Brook, . . .	.13	3.78	.0009	.0063	.0012	.09	.0037	.0000	.24	1.7
	Mountain Street Reservoir.*	.04	3.67	.0016	.0090	.0017	.09	.0051	.0000	.17	1.6

* See Notes.

TABLE NO. 2.—*Averages of Chemical Analyses, etc.*—Continued.

[Parts per 100,000.]

CITY OR TOWN.	Source.	Color.	Residue on Evaporation.	AMMONIA.			Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
					ALBUMINOID.						
				Free.	Total.	Sus-pended.		Nitrates.	Nitrites.		
North Andover,	Great Pond,	.12	3.39	.0022	.0190	.0026	.32	.0020	.0001	.32	1.2
Northborough,	Lower Reservoir,	.61	3.74	.0029	.0220	.0040	.22	.0051	.0000	.70	0.9
Northbridge,	Cook Allen Reservoir,*	.27	3.13	.0021	.0119	.0018	.19	.0019	.0000	.44	0.4
North Brookfield,	Doane Pond,	.53	3.21	.0065	.0246	.0047	.15	.0049	.0001	.50	0.5
	North Pond,	.52	3.35	.0056	.0271	.0053	.14	.0058	.0000	.59	0.5
Northfield,	Reservoir,	.16	2.94	.0006	.0077	.0009	.10	.0021	.0000	.28	0.7
Norwood,	Buckmaster Pond,	.10	3.04	.0073	.0176	.0030	.34	.0033	.0001	.23	0.7
Palmer,	Lower Reservoir,	.27	3.36	.0010	.0148	.0026	.13	.0025	.0000	.35	0.6
Peabody,	Brown's Pond,	.15	3.10	.0015	.0169	.0027	.52	.0033	.0001	.31	0.6
	Spring Pond,	.03	4.00	.0062	.0138	.0025	.63	.0012	.0000	.16	1.5
Pittsfield,	Ashley Lake,*	.31	4.57	.0080	.0219	.0046	.16	.0041	.0001	.43	2.3
	Ashley Brook,*	.14	6.13	.0052	.0157	.0022	.10	.0080	.0000	.27	4.6
	Hathaway Brook,	.05	8.28	.0020	.0074	.0008	.11	.0140	.0000	.14	6.7
	Mill Brook,	.03	5.03	.0011	.0059	.0013	.08	.0071	.0000	.12	3.6
	Sacket Brook,	.07	6.43	.0024	.0093	.0013	.09	.0141	.0000	.16	5.1
Plymouth,	Little South Pond,	.01	2.48	.0012	.0139	.0019	.68	.0016	.0000	.11	0.1
Randolph,	Great Pond,	.40	3.96	.0012	.0174	.0013	.53	.0042	.0000	.56	1.0
Rockport,	Cape Pond,	.27	9.12	.0114	.0301	.0090	3.52	.0077	.0001	.41	1.3
Rutland,	Muschopauge Lake,	.05	2.17	.0023	.0136	.0018	.18	.0020	.0000	.16	0.4
Salem,	Wenham Lake,	.12	5.47	.0047	.0187	.0039	.75	.0062	.0002	.30	2.2
	Longham Reservoir,	.94	6.26	.0085	.0309	.0047	.91	.0143	.0002	.91	1.8
Southbridge,	Hatchet Brook Reservoir.	.35	3.15	.0025	.0174	.0035	.15	.0033	.0000	.50	0.6
South Hadley,	Leaping Well Reservoir,	.03	2.59	.0027	.0138	.0045	.14	.0045	.0000	.13	0.5
	Buttery Brook Reservoir.	.17	3.78	.0039	.0136	.0043	.24	.0262	.0003	.24	0.9
Spencer,	Shaw Pond,	.03	2.31	.0013	.0125	.0009	.16	.0051	.0000	.12	0.7
Springfield,	Ludlow Canal,	.37	3.46	.0023	.0158	.0025	.14	.0048	.0000	.46	1.0
	Ludlow Reservoir,	.27	2.88	.0042	.0301	.0120	.13	.0055	.0001	.36	0.7
	Chapin Pond,	.04	2.25	.0010	.0193	.0030	.10	.0018	.0000	.22	0.4
	Five Mile Pond,	.07	2.50	.0058	.0210	.0025	.14	.0018	.0000	.25	0.4
Stockbridge,	Lake Averic,	.09	5.70	.0023	.0158	.0023	.07	.0028	.0000	.26	3.7
Taunton,	Assawompsett Pond,	.26	3.16	.0021	.0183	.0026	.48	.0016	.0000	.50	0.5
	Elder's Pond,	.05	2.75	.0011	.0160	.0022	.47	.0017	.0000	.27	0.4
Wakefield,	Crystal Lake,	.16	4.49	.0044	.0195	.0032	.57	.0073	.0001	.31	1.9

* See Notes.

TABLE NO. 2. — *Averages of Chemical Analyses, etc.* — Concluded.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Free.	Albuminoid.			Nitrates.	Nitrites.		
					Total.	Suspended.					
Wareham,	Jonathan's Pond,	.02	2.33	.0011	.0098	.0011	.70	.0015	.0000	.11	0.1
Wayland,	Snake Brook Reservoir.	.80	4.53	.0045	.0321	.0037	.28	.0062	.0000	.95	1.3
Westfield,	Montgomery Reservoir,	.48	2.65	.0032	.0192	.0036	.11	.0032	.0000	.59	0.3
	Tillotson Brook,	.08	2.61	.0011	.0070	.0010	.11	.0037	.0000	.18	0.5
West Springfield,	Darby Brook Reservoir,	.14	5.13	.0059	.0180	.0072	.18	.0057	.0001	.27	2.6
Weymouth,	Great Pond,	.69	3.89	.0023	.0189	.0020	.49	.0030	.0000	.77	0.5
Whitman,	Hobart's Pond,*	.60	6.22	.0057	.0318	.0041	.96	.0070	.0002	.81	1.8
Williamstown,	Flora Glen Reservoir,	.07	5.43	.0025	.0168	.0048	.07	.0034	.0000	.13	3.5
	Paul Brook,	.02	4.15	.0003	.0035	.0005	.06	.0149	.0000	.06	2.8
Winchester,	North Reservoir,	.08	4.51	.0040	.0232	.0048	.45	.0028	.0001	.27	2.0
	South Reservoir,	.09	3.15	.0054	.0214	.0028	.30	.0037	.0001	.27	1.2
	Middle Reservoir,	.20	3.42	.0081	.0323	.0072	.31	.0049	.0002	.39	1.1
Worcester,	Kent Reservoir,	.29	3.24	.0031	.0188	.0033	.17	.0070	.0000	.46	0.9
	Leicester Reservoir,	.23	3.01	.0041	.0153	.0021	.17	.0064	.0000	.40	0.8
	Upper Holden Reservoir.	.14	2.16	.0025	.0153	.0042	.13	.0024	.0000	.30	0.3
	Lower Holden Reservoir.	.07	2.26	.0022	.0116	.0021	.15	.0027	.0000	.19	0.6

* See Notes.

NOTES.

Metropolitan Water District, Nashua River. — The water of this source may have been unfavorably affected by the operations incident to the construction of the Wachusett Reservoir during the period covered by the analyses.

Metropolitan Water District, Wachusett Reservoir. — This is a new reservoir, not yet completed. A considerable quantity of water had been collected in April, 1904, and examinations of the source were begun at that time.

Amherst, Amethyst Brook Reservoir. — This reservoir was drawn off in 1904, and the soil and organic matter removed from its bottom, or covered with sand.

Athol, Phillipston Reservoir. — The water of this reservoir is filtered through a mechanical filter before being supplied to the town.

Athol, Buckman Brook Reservoir. — Previous to 1903 the reservoir had a very small capacity; a new reservoir of very much larger capacity was completed in the latter part of 1903. The analyses represent the results of examinations of both reservoirs.

Barre, Reservoir. — Much of the water entering is ground water, which deteriorates rapidly on exposure to light in the reservoir.

Brockton. — Since the introduction of water from Silver Lake in 1904 the use of the Brockton storage reservoir has been discontinued.

Deerfield, Roaring Brook. — This source was first used in 1903.

Gloucester, Haskell Brook Reservoir. — This reservoir was completed and first used in 1903.

Milford, Charles River, filtered. — The water of Charles River is filtered through an artificial sand filter, and is mingled with ground water obtained from wells near the river.

Natick, Dug Pond. — Dug Pond was abandoned as a source of water supply by Natick in 1903.

Northampton, Mountain Street Reservoir. — This reservoir, which receives water from West Brook, was completed in 1902. It was emptied again in 1903, and has not since been filled.

Northbridge, Cook Allen Reservoir. — This reservoir was completed in 1902.

Pittsfield. — The water of Ashley Lake flows down Ashley Brook, and is supplied thence to the city.

Whitman, Hobart's Pond. — This pond was abandoned as a source of water supply for Whitman at the end of the year 1904, and water was introduced from the works of the city of Brockton, water being supplied from Silver Lake.

First in importance in comparing the waters of the various sources are the conditions affecting their safety for drinking, and these depend chiefly upon their comparative freedom from danger of contamination by the wastes of human life and industry.

Nearly all of the water-sheds of streams, ponds and reservoirs in Massachusetts used as sources of water supply contain human habitations; but the use of unpurified water from sources polluted by the direct discharge of the sewage from the sewers of towns and villages has been discontinued. The degree of danger to which the health of a community is exposed by reason of the presence of population within the water-shed of the source from which it derives its supply of drinking water depends upon many circumstances. When sewage is discharged upon the ground within a water-shed, it may, if the soil is fine and impervious, or has been rendered impervious by frost, find its way directly over the surface and into a neighboring stream and thence into the distributing system of a public water supply, within a very few days or even a few hours of the time of its discharge. On the other hand, the circumstances may be such (as, for example, when a polluted stream flows into a large lake or reservoir) that the polluting matter may be many weeks or months in passing from the point where it enters the stream to the intake pipes of the water-supply system, and its noxious qualities may be wholly removed by sedimentation, oxidation or other processes which take place in ponds and reservoirs. If sewage or other polluting matter is discharged upon land having a porous soil it may sink into the ground and become purified by filtration before entering the stream to such an extent that the resulting pollution will not cause injury to health. In some cases, where the water-shed of a source of supply contains a large population, sewers have been constructed in which the sewage and foul drainage are removed and disposed of outside of the water-shed. Many of the sources of supply in the State are now protected by the enforcement of rules and regulations which have been established from time to time by the State Board of Health, under the provisions of public statutes, but there are still cases in which adequate sanitary protection is not provided. In some cases cities and towns have purchased and removed all of the buildings within the water-sheds of their sources of water supply, thus preventing further danger of pollution from these places.

While the number of persons living within a water-shed is in a general way an index of the extent to which a source is exposed to danger of sewage pollution, the actual danger to which users of the water are exposed depends, as has been indicated, upon many circumstances, and a thorough knowledge of the conditions affecting each source is necessary to determine definitely the relative sanitary quality of the various waters.

The sources in the water-sheds of which rules and regulations have been established for the protection of the purity of the water are the following: —

TABLE NO. 3.

Metropolitan Water District, Ashland Reservoir, Chestnut Hill Reservoir, Framingham Reservoir No. 2, Framingham Reservoir No. 3, Hopkinton Reservoir, Lake Cochituate, Nashua River, Sudbury Reservoir, Wachusett Reservoir.
Abington and Rockland, Big Sandy Pond.
Attleborough, Orr's Pond.*
Cambridge, Stony Brook Reservoir.
Danvers, Middleton Pond, Swan's Pond.
Easthampton, Bassett Brook.
Fall River, North Watuppa Lake.
Fitchburg, Falulah Reservoir, Scott Reservoir, Smith Reservoir, Meetinghouse Pond.
Greenfield, Glen Brook Reservoir.
Haverhill, Kenoza Lake, Millvale Reservoir.
Lincoln, Sandy Pond.
Marlborough, Lake Williams, Millham Brook Reservoir.
Northampton, Roberts' Meadow Brook, West Brook, Mountain Street Reservoir.
Norwood, Buckmaster Pond.
Peabody, Reservoir, Brown's Pond, Spring Pond.
Pittsfield, Ashley Lake, Ashley Brook, Sacket Brook, Hathaway Brook, Mill Brook.
Plymouth, Lout Pond, Little South Pond, Great South Pond.
Randolph and Holbrook, Great Pond.
Rockport, Cape Pond.
Salem, Wenham Lake, Longham Reservoir.
Springfield, Jabish Brook, Broad Brook, Axe Factory Brook, Ludlow Reservoir, Chapin Pond, Five Mile Pond, Higher Brook, lower basin of Van Horn Reservoir.
Taunton, Elder's Pond, Assawompsett Pond.
Wakefield, Crystal Lake.
Weymouth, Great Pond.
Worcester, Tatnuck Brook, Lynde Brook, Kettle Brook.

Sewers have been built which remove all or a part of the sewage from the water-sheds of the following sources: —

Metropolitan Water District, Framingham Reservoir No. 2, Sudbury Reservoir, Framingham Reservoir No. 3, Lake Cochituate.
Fall River, North Watuppa Lake.
Gardner, Crystal Lake.
Haverhill, Pentucket Lake.
Lynn, Saugus River.
Marlborough, Lake Williams.
Natick, Dug Pond.
Wakefield, Crystal Lake.

The approximate population living within the water-sheds of the various sources of supply has been computed from the best information available, and the results are presented in the following table: —

TABLE NO. 4. — *Surface-water Sources, arranged in Groups according to the Population on their Water-sheds.*

GROUP I. — *Sources having a Population upon their Water-sheds of Less than 10 per Square Mile.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Adams,	Bassett Brook.	Gloucester,	Dike's Brook Reservoir.
Athol,	Buckman Brook Reservoir.	Gloucester,	Haskell Brook Reservoir.
Brookfield,	Reservoir.	Gloucester,	Wallace Reservoir.
Cheshire,	Kitchen Brook.	Great Barrington,	East Mountain Reservoir.
Chicopee,	Morton Brook.	Hatfield,	Reservoir.
Dalton,	Egypt Brook Reservoir.	Hinsdale,	Storage Reservoir.

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* Not used directly as a source of water supply.

TABLE No. 4. — *Surface-water Sources, arranged in Groups, etc.* — Continued.

GROUP I. — *Sources having a Population upon their Water-sheds of Less than 10 per Square Mile* — Concluded.

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Holyoke,	Whiting Street Reservoir.	Southbridge,	Hatchet Brook Reservoir.
Holyoke,	Wright and Ashley Pond.	South Hadley,	Leaping Well Reservoir.
Lee,	Codding Brook.	Spencer,	Shaw Pond.
Leominster,	Morse Reservoir.	Stockbridge,	Lake Averic.
Lynn,	Glen Lewis Reservoir.	Wareham,	Jonathan's Pond.
Lynn,	Walden Reservoir.	West Springfield,	Darby Brook Reservoir.
Nantucket,	Wannacomet Pond.	Williamstown,	Flora Glen Reservoir.
North Adams,	Broad Brook.	Williamstown,	Paul Brook.
North Adams,	Notch Brook Reservoir.	Winchester,	North Reservoir.
Northbridge,	Cook Allen Reservoir.	Winchester,	Middle Reservoir.
Northfield,	Reservoir.	Winchester,	South Reservoir.
Pittsfield,	Ashley Lake.		

GROUP II. — *Sources having a Population upon their Water-sheds of from 10 to 50 per Square Mile.*

Metropolitan Water District.	Ashland Reservoir.	Maynard,	White Pond.
Adams,	Dry Brook.	New Bedford,	Old Storage Reservoir.
Amherst,	Amethyst Brook Reservoir.	Northampton,	Middle Reservoir.
Andover,	Haggett's Pond.	Northampton,	Mountain Street Reservoir.
Brockton,	Silver Lake.	Northampton,	West Brook.
Cambridge,	Lower Hobbs Brook Reservoir.	Northborough,	Lower Reservoir.
Cheshire,	Thunder Brook.	North Brookfield,	Doane Pond.
Chester,	Austin Brook.	North Brookfield,	North Pond.
Concord,	Sandy Pond.	Palmer,	Lower Reservoir.
Danvers,	Middleton Pond.	Pittsfield,	Ashley Brook.
Deerfield,	Roaring Brook.	Pittsfield,	Hathaway Brook.
Easthampton,	Bassett Brook.	Pittsfield,	Mill Brook.
Falmouth,	Long Pond.	Pittsfield,	Sacket Brook.
Fitchburg,	Falulah Reservoir.	Rutland,	Muschopauge Lake.
Fitchburg,	Scott Reservoir.	Springfield,	Chapin Pond.
Great Barrington,	Green River.	Springfield,	Five Mile Pond.
Greenfield,	Glen Brook Reservoir.	Springfield,	Ludlow Reservoir.
Haverhill,	Crystal Lake.	Wayland,	Snake Brook Reservoir.
Holyoke,	Manhan River.	Westfield,	Montgomery Reservoir.
Huntington,	Cold Brook.	Westfield,	Tillotson Brook.
Lenox,	Reservoir.	Worcester,	Kent Reservoir.
Leominster,	Fall Brook Reservoir.	Worcester,	Leicester Reservoir.
Leominster,	Haynes Reservoir.	Worcester,	Lower Holden Reservoir.
Lynn,	Breed's Reservoir.	Worcester,	Upper Holden Reservoir.

TABLE NO. 4.— *Surface-water Sources, arranged in Groups, etc.* — Concluded.

GROUP III.— *Sources having a Population upon their Water-sheds of from 50 to 100 per Square Mile.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Athol,	Phillipston Reservoir.	New Bedford,	Little Quittacas Pond.
Brockton,	Salisbury Brook Reservoir.	North Andover,	Great Pond.
Cambridge,	Stony Brook Reservoir.	Peabody,	Brown's Pond.
Chicopee,	Cooley Brook.	Plymouth,	Little South Pond.
Fitchburg,	Meetinghouse Pond.	Rockport,	Cape Pond.
Haverhill,	Johnson's Pond.	South Hadley,	Buttery Brook Reservoir.
Haverhill,	Millvale Reservoir.	Taunton,	Assawompsett Pond.
Hingham,	Fulling Mill Pond.	Taunton,	Elder's Pond.
Longmeadow,	Cooley Brook.	Westborough,	Sandra Pond.
Lynn,	Hawkes Reservoir.	Weymouth,	Great Pond.
New Bedford,	Great Quittacas Pond.		

GROUP IV.— *Sources having a Population upon their Water-sheds of from 100 to 200 per Square Mile.*

Metropolitan Water District.	Nashua River.	Lawrence,	Merrimack River, filtered.
Metropolitan Water District.	Wachusett Reservoir.	Lynn,	Saugus River.*
Abington,	Big Sandy Pond.	Marlborough,	Millham Brook Reservoir.
Barre,	Reservoir.	Milford,	Charles River, filtered.
Fall River,	North Watuppa Lake.*	Montague,	Lake Pleasant.
Haverhill,	Kenoza Lake.	Norwood,	Buckmaster Pond.
Hingham,	Accord Pond.	Randolph,	Great Pond.
Hudson,	Gates Pond.	Salem,	Longham Reservoir.
Ipswich,	Dow's Brook Reservoir.	Salem,	Wenham Lake.

GROUP V.— *Sources having a Population upon their Water-sheds of more than 200 per Square Mile.*

Metropolitan Water District.	Hopkinton Reservoir.	Haverhill,	Pentucket Lake.*
Metropolitan Water District.	Framingham Reservoir No. 2.†	Lynn,	Birch Reservoir.
Metropolitan Water District.	Sudbury Reservoir.†	Marlborough,	Lake Williams.†
Metropolitan Water District.	Framingham Reservoir No. 3.†	Natick,	Dug Pond.‡
Metropolitan Water District.	Lake Cochituate.†	Peabody,	Spring Pond.
Cambridge,	Fresh Pond.†	Wakefield,	Crystal Lake.*
Gardner,	Crystal Lake.*	Whitman,	Hobart's Pond.‡

* Sewers remove a portion of the sewage from within the water-shed.

† Sewers have been built to remove sewage from water-shed.

‡ Abandoned.

Next in importance to the freedom of the water from danger of pollution by sewage is its relative freedom from organic matter; and the best index of the quantity of organic matter present in surface waters is furnished by the determination of the ammonia, especially the albuminoid ammonia. The total quantity of albuminoid ammonia in the various sources of water supply and the quantity of albuminoid ammonia in suspension are shown in the following table, in which the waters have been arranged in accordance with the average total quantity of albuminoid ammonia for the past five years. The averages of the maximum amounts in each year of the five are also presented. For convenience, the quantity of free ammonia is also included in the table.

TABLE NO. 5. — *Albuminoid Ammonia and Free Ammonia in Surface Waters, arranged in Order of Albuminoid Ammonia.*

[Parts per 100,000.]

City or Town.	Source.	Albuminoid Ammonia.				Free Ammonia, Average for Five Years.
		Total.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Great Barrington,	Green River,	.0031	.0044	.0060	.0004	.0012
Williamstown,	Paul Brook,	.0035	.0045	.0064	.0005	.0003
Greenfield,	Glen Brook Reservoir,	.0038	.0060	.0072	.0002	.0007
Adams,	Bassett Brook,	.0039	.0054	.0062	.0006	.0005
Cheshire,	Thunder Brook,	.0039	.0043	.0066	.0004	.0009
Deerfield,	Roaring Brook,	.0039	.0055	.0060	.0006	.0009
Chicopee,	Morton Brook,	.0044	.0059	.0098	.0008	.0006
Cheshire,	Kitchen Brook,	.0052	.0090	.0196	.0022	.0013
Chester,	Austin Brook,	.0055	.0055	.0068	.0004	.0006
Hatfield,	Reservoir,	.0059	.0132	.0276	.0007	.0016
Longmeadow,	Cooley Brook,	.0059	.0079	.0118	.0016	.0015
Pittsfield,	Mill Brook,	.0059	.0107	.0224	.0013	.0011
Northampton,	West Brook,	.0063	.0158	.0158	.0012	.0009
Westfield,	Tillotson Brook,	.0070	.0090	.0108	.0010	.0011
Pittsfield,	Hathaway Brook,	.0074	.0109	.0160	.0008	.0020
Great Barrington,	East Mountain Reservoir,	.0075	.0096	.0108	.0020	.0059
Montague,	Lake Pleasant,	.0077	.0098	.0118	.0011	.0018
Northfield,	Reservoir,	.0077	.0113	.0164	.0009	.0006
North Adams,	Broad Brook,	.0085	.0146	.0204	.0012	.0019
Easthampton,	Bassett Brook,	.0089	.0158	.0278	.0019	.0011

TABLE NO. 5. — *Albuminoid Ammonia and Free Ammonia in Surface Waters, arranged in Order of Albuminoid Ammonia* — Continued.

[Parts per 100,000.]

CITY OR TOWN.	SOURCE.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Adams,	Dry Brook,	.0090	.0129	.0194	.0010	.0013
Northampton,	Mountain Street Reservoir,	.0090	.0120	.0122	.0017	.0016
Pittsfield,	Sacket Brook,	.0093	.0144	.0310	.0013	.0024
Lee,	Codding Brook,	.0095	.0126	.0166	.0008	.0014
Lawrence,	Merrimack River, filtered,	.0097	.0138	.0172	.0009	.0124
Wareham,	Jonathan's Pond,	.0098	.0124	.0200	.0011	.0011
Falmouth,	Long Pond,	.0099	.0127	.0184	.0009	.0014
Milford,	Charles River, filtered,	.0100	.0161	.0168	-	.0018
North Adams,	Notch Brook Reservoir,	.0101	.0161	.0240	.0022	.0047
Dalton,	Egypt Brook Reservoir,	.0110	.0128	.0158	.0015	.0014
Worcester,	Lower Holden Reservoir,	.0116	.0149	.0162	.0021	.0022
Maynard,	White Pond,	.0119	.0162	.0248	.0019	.0008
Northbridge,	Cook Allen Reservoir,	.0119	.0155	.0192	.0018	.0021
Lenox,	Reservoir,	.0122	.0173	.0220	.0020	.0015
Spencer,	Shaw Pond,	.0125	.0154	.0188	.0009	.0013
Huntington,	Cold Brook,	.0126	.0177	.0190	.0015	.0015
Northampton,	Middle Reservoir,	.0127	.0216	.0260	.0024	.0013
Hingham,	Accord Pond,	.0128	.0152	.0180	.0013	.0010
Concord,	Sandy Pond,	.0131	.0156	.0210	.0014	.0011
Holyoke,	Manhan River,	.0133	.0196	.0276	.0022	.0014
Metropolitan Water District,	Tap in Quincy,	.0134	.0160	.0184	.0015	.0010
Brockton,	Silver Lake,	.0136	.0208	.0286	.0018	.0010
Fitchburg,	Meetinghouse Pond,	.0136	.0171	.0198	.0019	.0016
Rutland,	Muschopauge Lake,	.0136	.0174	.0250	.0018	.0023
South Hadley,	Buttery Brook Reservoir,	.0136	.0180	.0200	.0043	.0039
Peabody,	Spring Pond,	.0138	.0150	.0166	.0025	.0062
South Hadley,	Leaping Well Reservoir,	.0138	.0196	.0262	.0045	.0027
Chicopee,	Cooley Brook,	.0139	.0228	.0336	.0024	.0019
Plymouth,	Little South Pond,	.0139	.0169	.0204	.0019	.0012
Metropolitan Water District,	Tap in Revere,	.0143	.0170	.0186	.0019	.0014
Amherst,	Amethyst Brook Reservoir,	.0143	.0201	.0364	.0015	.0021

TABLE NO. 5.—*Albuminoid Ammonia and Free Ammonia in Surface Waters, arranged in Order of Albuminoid Ammonia*— Continued.

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Metropolitan Water District,	Tap in State House, . . .	.0144	.0175	.0190	.0018	.0015
Palmer, ...	Lower Reservoir, ...	.0148	.0209	.0350	.0026	.0010
Haverhill, ...	Kenoza Lake, ...	.0149	.0167	.0176	.0016	.0013
Hudson, ...	Gates Pond, ...	.0151	.0184	.0230	.0019	.0028
Andover, ...	Haggett's Pond, ...	.0152	.0171	.0192	.0012	.0014
Leominster, ...	Fall Brook Reservoir, . . .	.0152	.0184	.0198	.0028	.0013
Metropolitan Water District,	Spot Pond, ...	.0153	.0198	.0234	.0022	.0018
Worcester, ...	Leicester Reservoir, . . .	.0153	.0181	.0200	.0021	.0041
Worcester, ...	Upper Holden Reservoir, . .	.0153	.0227	.0268	.0042	.0025
Metropolitan Water District,	Wachusett Reservoir, . . .	.0154	.0192	.0192	.0031	.0034
Metropolitan Water District,	Chestnut Hill Reservoir, . .	.0155	.0188	.0210	.0020	.0025
Metropolitan Water District,	Sudbury Reservoir, . . .	.0156	.0207	.0242	.0024	.0032
Metropolitan Water District,	Framingham Reservoir No. 3, .	.0156	.0206	.0284	.0025	.0023
Abington, ...	Big Sandy Pond, ...	.0157	.0188	.0226	.0018	.0022
Pittsfield, ...	Ashley Brook, ...	.0157	.0216	.0256	.0022	.0052
Springfield, ...	Ludlow Canal, ...	.0158	.0276	.0440	.0025	.0023
Stockbridge, ...	Lake Averic, ...	.0158	.0200	.0226	.0023	.0023
Haverhill, ...	Pentucket Lake, ...	.0160	.0186	.0244	.0019	.0010
Taunton, ...	Elder's Pond, ...	.0160	.0190	.0206	.0022	.0011
Haverhill, ...	Johnson's Pond, ...	.0166	.0200	.0266	.0016	.0012
Haverhill, ...	Crystal Lake, ...	.0166	.0192	.0216	.0019	.0013
Holyoke, ...	Wright and Ashley Pond, . .	.0166	.0215	.0238	.0032	.0025
Metropolitan Water District,	Nashua River, ...	.0168	.0222	.0306	.0025	.0021
Williamstown, . . .	Flora Glen Reservoir, . . .	.0168	.0249	.0446	.0048	.0025
New Bedford, ...	Little Quittacas Pond, . . .	.0169	.0196	.0244	.0022	.0015
Peabody, ...	Brown's Pond, ...	.0169	.0201	.0222	.0027	.0015
Gardner, ...	Crystal Lake, ...	.0173	.0210	.0248	.0028	.0025
New Bedford, ...	Tap at City Hall, ...	.0174	.0207	.0228	.0019	.0016
Randolph, ...	Great Pond, ...	.0174	.0206	.0236	.0013	.0012
Southbridge, ...	Hatchet Brook Reservoir, . .	.0174	.0261	.0316	.0035	.0025
Norwood, ...	Buckmaster Pond, . . .	.0176	.0234	.0322	.0030	.0073

TABLE NO. 5. — *Albuminoid Ammonia and Free Ammonia in Surface Waters, arranged in Order of Albuminoid Ammonia* — Continued.

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Fall River,	North Watuppa Lake,	.0180	.0216	.0252	.0025	.0013
New Bedford,	Great Quittacas Pond,	.0180	.0208	.0268	.0026	.0017
West Springfield,	Darby Brook Reservoir,	.0180	.0255	.0300	.0072	.0059
Taunton,	Assawompsett Pond,	.0183	.0233	.0340	.0026	.0021
Gloucester,	Dike's Brook Reservoir,	.0186	.0241	.0300	.0032	.0030
Natick,	Dug Pond,	.0187	.0213	.0242	.0024	.0077
Salem,	Wenham Lake,	.0187	.0258	.0292	.0039	.0047
Worcester,	Kent Reservoir,	.0188	.0276	.0324	.0033	.0031
Weymouth,	Great Pond,	.0189	.0214	.0248	.0020	.0023
North Andover,	Great Pond,	.0190	.0228	.0272	.0026	.0022
Fitchburg,	Scott Reservoir,	.0192	.0265	.0332	.0056	.0057
Westfield,	Montgomery Reservoir,	.0192	.0246	.0356	.0036	.0032
Danvers,	Middleton Pond,	.0193	.0222	.0250	.0025	.0017
Springfield,	Chapin Pond,	.0193	.0216	.0254	.0030	.0010
Wakefield,	Crystal Lake,	.0195	.0231	.0280	.0032	.0044
Ipswich,	Dow's Brook Reservoir,	.0196	.0269	.0308	.0026	.0022
Leominster,	Morse Reservoir,	.0198	.0249	.0316	.0045	.0032
Metropolitan Water District,	Ashland Reservoir,	.0205	.0242	.0294	.0020	.0021
Haverhill,	Millvale Reservoir,	.0207	.0248	.0296	.0022	.0017
Metropolitan Water District,	Lake Cochituate,	.0208	.0271	.0308	.0033	.0030
Lynn,	Breed's Reservoir,	.0208	.0269	.0308	.0034	.0039
Metropolitan Water District,	Hopkinton Reservoir,	.0210	.0267	.0302	.0029	.0033
Hinsdale,	Storage Reservoir,	.0210	.0299	.0300	.0076	.0044
Springfield,	Five Mile Pond,	.0210	.0262	.0364	.0025	.0058
Athol,	Buckman Brook Reservoir,	.0212	.0328	.0432	.0043	.0026
Gloucester,	Haskell Brook Reservoir,	.0212	.0353	.0398	.0058	.0053
Winchester,	South Reservoir,	.0214	.0260	.0302	.0028	.0054
Lynn,	Tap,	.0215	.0315	.0364	.0027	.0030
Pittsfield,	Ashley Lake,	.0219	.0310	.0312	.0046	.0080
Northborough,	Lower Reservoir,	.0220	.0295	.0352	.0040	.0029
Marlborough,	Lake Williams,	.0225	.0260	.0292	.0041	.0022

TABLE NO. 5. — *Albuminoid Ammonia and Free Ammonia in Surface Waters, arranged in Order of Albuminoid Ammonia* — Concluded.

[Parts per 100,000.]

CITY OR TOWN.	SOURCE.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Metropolitan Water District,	Framingham Reservoir No. 2,	.0226	.0297	.0372	.0024	.0032
Cambridge,	Fresh Pond,	.0227	.0358	.0578	.0055	.0053
Gloucester,	Wallace Reservoir,	.0229	.0301	.0384	.0060	.0037
Winchester,	North Reservoir,	.0232	.0298	.0432	.0048	.0040
Brockton,	Salisbury Brook Reservoir,	.0233	.0303	.0336	.0036	.0019
Cambridge,	Stony Brook Reservoir,	.0234	.0290	.0306	.0033	.0030
Holyoke,	Whiting Street Reservoir,	.0237	.0362	.0514	.0069	.0026
Nantucket,	Wannacomet Pond,	.0237	.0573	.1540	.0091	.0037
Lynn,	Birch Reservoir,	.0245	.0345	.0482	.0043	.0051
North Brookfield,	Doane Pond,	.0246	.0331	.0428	.0047	.0065
Lynn,	Hawkes Reservoir,	.0248	.0344	.0424	.0034	.0034
Marlborough,	Millham Brook Reservoir,	.0258	.0335	.0436	.0057	.0054
New Bedford,	Old Storage Reservoir,	.0264	.0376	.0580	.0041	.0035
Cambridge,	Lower Hobbs Brook Reservoir,	.0265	.0319	.0358	.0045	.0029
North Brookfield,	North Pond,	.0271	.0357	.0444	.0053	.0056
Lee,	Upper Reservoir on Codding Brook.	.0278	.0397	.0494	.0069	.0070
Lynn,	Walden Reservoir,	.0286	.0366	.0444	.0066	.0034
Lynn,	Glen Lewis Reservoir,	.0291	.0483	.0860	.0084	.0062
Rockport,	Cape Pond,	.0301	.0430	.0584	.0090	.0114
Springfield,	Ludlow Reservoir,	.0301	.1121	.2670	.0120	.0042
Salem,	Longham Reservoir,	.0309	.0479	.0575	.0047	.0085
Whitman,	Hobart's Pond,	.0318	.0399	.0420	.0041	.0057
Leominster,	Haynes Reservoir,	.0319	.0429	.0575	.0108	.0047
Wayland,	Snake Brook Reservoir,	.0321	.0338	.0558	.0037	.0045
Winchester,	Middle Reservoir,	.0323	.0456	.0693	.0072	.0081
Lynn,	Saugus River,	.0331	.0499	.0584	.0037	.0050
Athol,	Phillipston Reservoir,	.0334	.0575	.1300	.0110	.0049
Barre,	Reservoir,	.0365	.0365	.0366	.0070	.0100

In the foregoing table, of the first 27 waters in which the average albuminoid ammonia has been less than .0100 parts per 100,000, 19 are streams, 3 are natural ponds — viz., Lake Pleasant in Montague, Jonathan's Pond in Wareham and Long Pond in Falmouth — and 5 are artificial storage reservoirs — Greenfield, Hatfield, Great Barrington, Northfield and the Mountain Street Reservoir in Northampton. Three of these reservoirs — those at Hatfield, Northfield and Great Barrington — are very small, while the Mountain Street Reservoir of the city of Northampton is new, and the analyses cover a period of less than a year. On the other hand, among the 28 waters at the foot of the list having an average of more than .0225 of a part per 100,000 of albuminoid ammonia, there are no streams and only two natural ponds, — Cape Pond, in Rockport, and Fresh Pond, in Cambridge, — the latter being supplied chiefly, however, with water from the Stony Brook storage reservoir. With these exceptions all are storage reservoirs, all but one of which — Hawkes Reservoir at Lynn — were formed by the flooding of areas from which the soil, stumps and other organic matter were not removed. Hawkes Reservoir receives part of its water from the highly polluted Saugus River. The reservoir which stands at the foot of this list — that at Barre — is a comparatively small one; and the poor quality of the water is largely due to the fact that much of the water which enters the reservoir is spring water, which deteriorates rapidly on exposure to light. For convenience in comparison, this table has been sub-divided into three classes, viz.: (1) streams; (2) natural ponds; (3) artificial reservoirs.

TABLE NO. 6. — *Albuminoid Ammonia and Free Ammonia in the Water of Streams, arranged in Order of Albuminoid Ammonia.*

[Parts per 100,000.]

CITY OR TOWN.	SOURCE.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Great Barrington,	Green River,	.0031	.0044	.0060	.0004	.0012
Williamstown,	Paul Brook,	.0035	.0045	.0064	.0005	.0003
Adams,	Bassett Brook,	.0039	.0054	.0062	.0006	.0005
Cheshire,	Thunder Brook,	.0039	.0043	.0066	.0004	.0009
Deerfield,	Roaring Brook,	.0039	.0055	.0060	.0006	.0009
Chicopee,	Morton Brook,	.0044	.0059	.0098	.0008	.0006
Cheshire,	Kitchen Brook,	.0052	.0090	.0196	.0022	.0013
Chester,	Austin Brook,	.0055	.0055	.0068	.0004	.0006
Longmeadow,	Cooley Brook,	.0059	.0079	.0118	.0016	.0015
Pittsfield,	Mill Brook,	.0059	.0107	.0224	.0013	.0011
Northampton,	West Brook,	.0063	.0158	.0158	.0012	.0009

TABLE NO. 6. — *Albuminoid Ammonia and Free Ammonia in the Water of Streams, arranged in Order of Albuminoid Ammonia* — Concluded.

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Westfield,	Tillotson Brook,	.0070	.0090	.0108	.0010	.0011
Pittsfield,	Hathaway Brook,	.0074	.0109	.0160	.0008	.0020
North Adams,	Broad Brook,	.0085	.0146	.0204	.0012	.0019
Easthampton,	Bassett Brook,	.0089	.0158	.0278	.0019	.0011
Adams,	Dry Brook,	.0090	.0129	.0194	.0010	.0013
Pittsfield,	Sacket Brook,	.0093	.0144	.0310	.0013	.0024
Lee,	Codding Brook,	.0095	.0126	.0166	.0008	.0014
Lawrence,	Merrimack River, filtered,	.0097	.0138	.0172	.0009	.0124
Milford,	Charles River, filtered,	.0100	.0161	.0168	–	.0018
Huntington,	Cold Brook,	.0126	.0177	.0190	.0015	.0015
Holyoke,	Manhan River,	.0133	.0196	.0276	.0022	.0014
Chicopee,	Cooley Brook,	.0139	.0228	.0336	.0024	.0019
Pittsfield,	Ashley Brook,	.0157	.0216	.0256	.0022	.0052
Springfield,	Ludlow canal,	.0158	.0276	.0440	.0025	.0023
Metropolitan Water District,	Nashua River,*	.0168	.0222	.0306	.0025	.0021
Lynn,	Saugus River,	.0331	.0499	.0584	.0037	.0050

* Affected by construction of Wachusett Reservoir.

TABLE NO. 7.— *Albuminoid Ammonia and Free Ammonia in the Water of Lakes and Ponds, arranged in Order of Albuminoid Ammonia.*

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Montague,	Lake Pleasant,	.0077	.0098	.0118	.0011	.0018
Wareham,	Jonathan's Pond,	.0098	.0124	.0200	.0011	.0011
Falmouth,	Long Pond,	.0099	.0127	.0184	.0009	.0014

TABLE NO. 7.— *Albuminoid Ammonia and Free Ammonia in the Water of Lakes and Ponds, arranged in Order of Albuminoid Ammonia* — Continued.

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Maynard,	White Pond,	.0119	.0162	.0248	.0019	.0008
Spencer,	Shaw Pond,	.0125	.0154	.0188	.0009	.0013
Hingham,	Accord Pond,	.0128	.0152	.0180	.0013	.0010
Concord,	Sandy Pond,	.0131	.0156	.0210	.0014	.0011
Brockton,	Silver Lake,	.0136	.0208	.0286	.0018	.0010
Fitchburg,	Meetinghouse Pond,	.0136	.0171	.0198	.0019	.0016
Rutland,	Muschopauge Lake,	.0136	.0174	.0250	.0018	.0023
Peabody,	Spring Pond,	.0138	.0150	.0166	.0025	.0062
Plymouth,	Little South Pond,	.0139	.0169	.0204	.0019	.0012
Haverhill,	Kenoza Lake,	.0149	.0167	.0176	.0016	.0013
Hudson,	Gates Pond,	.0151	.0184	.0230	.0019	.0028
Andover,	Haggett's Pond,	.0152	.0171	.0192	.0012	.0014
Abington,	Big Sandy Pond,	.0157	.0188	.0226	.0018	.0022
Stockbridge,	Lake Averic,	.0158	.0200	.0226	.0023	.0023
Haverhill,	Pentucket Lake,	.0160	.0186	.0244	.0019	.0010
Taunton,	Elder's Pond,	.0160	.0190	.0206	.0022	.0011
Haverhill,	Johnson's Pond,	.0166	.0200	.0266	.0016	.0012
Haverhill,	Crystal Lake,	.0166	.0192	.0216	.0019	.0013
New Bedford,	Little Quittacas Pond,	.0169	.0196	.0244	.0022	.0015
Peabody,	Brown's Pond,	.0169	.0201	.0222	.0027	.0015
Gardner,	Crystal Lake,	.0173	.0210	.0248	.0028	.0025
Randolph,	Great Pond,	.0174	.0206	.0236	.0013	.0012
Norwood,	Buckmaster Pond,	.0176	.0234	.0322	.0030	.0073
Fall River,	North Watuppa Lake,	.0180	.0216	.0252	.0025	.0013
New Bedford,	Great Quittacas Pond,	.0180	.0208	.0268	.0026	.0017
Taunton,	Assawompsett Pond,	.0183	.0233	.0340	.0026	.0021
Natick,	Dug Pond,	.0187	.0213	.0242	.0024	.0077
Salem,	Wenham Lake,	.0187	.0258	.0292	.0039	.0047
Weymouth,	Great Pond,	.0189	.0214	.0248	.0020	.0023
North Andover,	Great Pond,	.0190	.0228	.0272	.0026	.0022
Danvers,	Middleton Pond,	.0193	.0222	.0250	.0025	.0017
Springfield,	Chapin Pond,	.0193	.0216	.0254	.0030	.0010

TABLE No. 7. — *Albuminoid Ammonia and Free Ammonia in the Water of Lakes and Ponds, arranged in Order of Albuminoid Ammonia* — Concluded.

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Wakefield, ...	Crystal Lake, ...	.0195	.0231	.0280	.0032	.0044
Metropolitan Water District,	Lake Cochituate, ...	.0208	.0271	.0308	.0033	.0030
Springfield, ...	Five Mile Pond, ...	.0210	.0262	.0364	.0025	.0058
Pittsfield, ...	Ashley Lake, ...	.0219	.0310	.0312	.0046	.0080
Marlborough, ...	Lake Williams, ...	.0225	.0260	.0292	.0041	.0022
Cambridge, ...	Fresh Pond, ...	.0227	.0358	.0578	.0055	.0053
Nantucket, ...	Wannacomet Pond, ...	.0237	.0573	.1540	.0091	.0037
Rockport, ...	Cape Pond, ...	.0301	.0430	.0584	.0090	.0114

TABLE No. 8. — *Albuminoid Ammonia and Free Ammonia in the Water of Storage Reservoirs, arranged in Order of Albuminoid Ammonia.*

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Greenfield, ...	Glen Brook Reservoir, ...	.0038	.0060	.0072	.0002	.0007
Hatfield, ...	Reservoir, ...	.0059	.0132	.0276	.0007	.0016
Great Barrington, ...	East Mountain Reservoir, . .	.0075	.0096	.0108	.0020	.0059
Northfield, ...	Reservoir, ...	.0077	.0113	.0164	.0009	.0006
Northampton, ...	Mountain Street Reservoir, . .	.0090	.0120	.0122	.0017	.0016
North Adams, ...	Notch Brook Reservoir, . .	.0101	.0161	.0240	.0022	.0047
Dalton, ...	Egypt Brook Reservoir, . . .	.0110	.0128	.0158	.0015	.0014
Worcester, ...	Lower Holden Reservoir, . .	.0116	.0149	.0162	.0021	.0022
Northbridge, ...	Cook Allen Reservoir, . . .	.0119	.0155	.0192	.0018	.0021
Lenox, ...	Reservoir, ...	.0122	.0173	.0220	.0020	.0015
Northampton, ...	Middle Reservoir, ...	.0127	.0216	.0260	.0024	.0013
South Hadley, ...	Buttery Brook Reservoir, . .	.0136	.0180	.0200	.0043	.0039

TABLE No. 8. — *Albuminoid Ammonia and Free Ammonia in the Water of Storage Reservoirs, arranged in Order of Albuminoid Ammonia* — Continued.

[Parts per 100,000.]

CITY OR TOWN.	Source.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
South Hadley,	Leaping Well Reservoir,	.0138	.0196	.0262	.0045	.0027
Amherst,	Amethyst Brook Reservoir,	.0143	.0201	.0364	.0015	.0021
Palmer,	Lower Reservoir,	.0148	.0209	.0350	.0026	.0010
Leominster,	Fall Brook Reservoir,	.0152	.0184	.0198	.0028	.0013
Worcester,	Leicester Reservoir,	.0153	.0181	.0200	.0021	.0041
Worcester,	Upper Holden Reservoir,	.0153	.0227	.0268	.0042	.0025
Metropolitan Water District,	Wachusett Reservoir,	.0154	.0192	.0192	.0031	.0034
Metropolitan Water District,	Sudbury Reservoir,	.0156	.0207	.0242	.0024	.0032
Metropolitan Water District,	Framingham Reservoir No. 3,	.0156	.0206	.0284	.0025	.0023
Holyoke,	Wright and Ashley Pond,	.0166	.0215	.0238	.0032	.0025
Williamstown,	Flora Glen Reservoir,	.0168	.0249	.0446	.0048	.0025
Southbridge,	Hatchet Brook Reservoir,	.0174	.0261	.0316	.0035	.0025
West Springfield,	Darby Brook Reservoir,	.0180	.0255	.0300	.0072	.0059
Gloucester,	Dike's Brook Reservoir,	.0186	.0241	.0300	.0032	.0030
Worcester,	Kent Reservoir,	.0188	.0276	.0324	.0033	.0031
Fitchburg,	Scott Reservoir,	.0192	.0265	.0332	.0056	.0057
Westfield,	Montgomery Reservoir,	.0192	.0246	.0356	.0036	.0032
Ipswich,	Dow's Brook Reservoir,	.0196	.0269	.0308	.0026	.0022
Leominster,	Morse Reservoir,	.0198	.0249	.0316	.0045	.0032
Metropolitan Water District,	Ashland Reservoir,	.0205	.0242	.0294	.0020	.0021
Haverhill,	Millvale Reservoir,	.0207	.0248	.0296	.0022	.0017
Lynn,	Breed's Reservoir,	.0208	.0269	.0308	.0034	.0039
Metropolitan Water District,	Hopkinton Reservoir,	.0210	.0267	.0302	.0029	.0033
Hinsdale,	Storage Reservoir,	.0210	.0299	.0300	.0076	.0044
Athol,	Buckman Brook Reservoir,	.0212	.0328	.0432	.0043	.0026
Gloucester,	Haskell Brook Reservoir,	.0212	.0353	.0398	.0058	.0053
Winchester,	South Reservoir,	.0214	.0260	.0302	.0028	.0054
Northborough,	Lower Reservoir,	.0220	.0295	.0352	.0040	.0029
Metropolitan Water District,	Framingham Reservoir No. 2,	.0226	.0297	.0372	.0024	.0032
Gloucester,	Wallace Reservoir,	.0229	.0301	.0384	.0060	.0037
Winchester,	North Reservoir,	.0232	.0298	.0432	.0048	.0040

TABLE NO. 8. — *Albuminoid Ammonia and Free Ammonia in the Water of Storage Reservoirs, arranged in Order of Albuminoid Ammonia* — Concluded.

[Parts per 100,000.]

CITY OR TOWN.	SOURCE.	ALBUMINOID AMMONIA.				Free Ammonia, Average for Five Years.
		TOTAL.			Suspended, Average for Five Years.	
		Average for Five Years.	Average of the Maxima for Five Years.	Maximum during Five Years.		
Brockton,	Salisbury Brook Reservoir,	.0233	.0303	.0336	.0036	.0019
Cambridge,	Stony Brook Reservoir,	.0234	.0290	.0306	.0033	.0030
Holyoke,	Whiting Street Reservoir,	.0237	.0362	.0514	.0069	.0026
Lynn,	Birch Reservoir,	.0245	.0345	.0482	.0043	.0051
North Brookfield,	Doane Pond,	.0246	.0331	.0428	.0047	.0065
Lynn,	Hawkes Reservoir,	.0248	.0344	.0424	.0034	.0034
Marlborough,	Millham Brook Reservoir,	.0258	.0335	.0436	.0057	.0054
New Bedford,	Old Storage Reservoir,	.0264	.0376	.0580	.0041	.0035
Cambridge,	Lower Hobbs Brook Reservoir,	.0265	.0319	.0358	.0045	.0029
North Brookfield,	North Pond,	.0271	.0357	.0444	.0053	.0056
Lee,	Upper Reservoir on Codding Brook.	.0278	.0397	.0494	.0069	.0070
Lynn,	Walden Reservoir,	.0286	.0366	.0444	.0066	.0034
Lynn,	Glen Lewis Reservoir,	.0291	.0483	.0860	.0084	.0062
Springfield,	Ludlow Reservoir,	.0301	.1121	.2670	.0120	.0042
Salem,	Longham Reservoir,	.0309	.0479	.0575	.0047	.0085
Whitman,	Hobart's Pond,	.0318	.0399	.0420	.0041	.0057
Leominster,	Haynes Reservoir,	.0319	.0429	.0575	.0108	.0047
Wayland,	Snake Brook Reservoir,	.0321	.0338	.0558	.0037	.0045
Winchester,	Middle Reservoir,	.0323	.0456	.0693	.0072	.0081
Athol,	Phillipston Reservoir,	.0334	.0575	.1300	.0110	.0049
Barre,	Reservoir,	.0365	.0365	.0366	.0070	.0100

The quantity of free ammonia present in the various surface-water supplies of the State is, for the most part, small, and its presence is due to various causes. Free ammonia is a characteristic ingredient of sewage, and in sewage polluted waters it is present in large quantities; but free ammonia is a product of decay, and there are many conditions which cause its development or disappearance in surface waters. Some of the deeper lakes and ponds show a decided increase in free ammonia in the late fall or early winter, due to the accumulation of ammonia during the warm weather in the lower stagnant layers, which is distributed throughout the water as the coming of cold weather puts these deeper layers into circulation. In ponds and reservoirs in which there are excessive growths of organisms, such as the Middle Reservoir at Winchester, the Barre Reservoir and Cape Pond, Rockport, free ammonia is present frequently in large quantity. The quantity of free ammonia present in the various surface-water supplies is given in Table No. 9, and the quantity in the streams, ponds and reservoirs separately is given in tables Nos. 10, 11 and 12.

TABLE NO. 9. — *Free Ammonia in Surface Waters.*

[Parts per 100,000.]

Williamstown, Paul Brook,	.0003
Adams, Bassett Brook,	.0005
Chester, Austin Brook,	.0006
Chicopee, Morton Brook,	.0006
Northfield, reservoir,	.0006
Greenfield, Glen Brook Reservoir,	.0007
Maynard, White Pond,	.0008
Cheshire, Thunder Brook,	.0009
Deerfield, Roaring Brook,	.0009
Northampton, West Brook,	.0009
Metropolitan Water District, tap in Quincy,	.0010
Brockton, Silver Lake,	.0010
Haverhill, Pentucket Lake,	.0010
Hingham, Accord Pond,	.0010
Palmer, Lower Reservoir,	.0010
Springfield, Chapin Pond,	.0010
Concord, Sandy Pond,	.0011
Easthampton, Bassett Brook,	.0011
Pittsfield, Mill Brook,	.0011
Taunton, Elder's Pond,	.0011
Wareham, Jonathan's Pond,	.0011
Westfield, Tillotson Brook,	.0011
Great Barrington, Green River,	.0012
Haverhill, Johnson's Pond,	.0012
Plymouth, Little South Pond,	.0012
Randolph, Great Pond,	.0012
Adams, Dry Brook,	.0013
Cheshire, Kitchen Brook,	.0013
Fall River, North Watuppa Lake,	.0013
Haverhill, Crystal Lake,	.0013
Haverhill, Kenoza Lake,	.0013
Leominster, Fall Brook Reservoir,	.0013
Northampton, Middle Reservoir,	.0013
Spencer, Shaw Pond,	.0013
Metropolitan Water District, tap in Revere,	.0014
Andover, Haggett's Pond,	.0014
Dalton, Egypt Brook Reservoir,	.0014
Falmouth, Long Pond,	.0014
Holyoke, Manhan River,	.0014
Lee, Codding Brook,	.0014
Metropolitan Water District, tap in State House,	.0015
Huntington, Cold Brook,	.0015
Lenox, reservoir,	.0015
Longmeadow, Cooley Brook,	.0015
New Bedford, Little Quittacas Pond,	.0015
Peabody, Brown's Pond,	.0015
Fitchburg, Meetinghouse Pond,	.0016
Hatfield, reservoir,	.0016
New Bedford, tap in City Hall,	.0016
Northampton, Mountain Street Reservoir,	.0016
Danvers, Middleton Pond,	.0017
Haverhill, Millvale Reservoir,	.0017
New Bedford, Great Quittacas Pond,	.0017
Metropolitan Water District, Spot Pond,	.0018
Milford, Charles River, filtered,	.0018
Montague, Lake Pleasant,	.0018
Brockton, Salisbury Brook Reservoir,	.0019
Chicopee, Cooley Brook,	.0019
North Adams, Broad Brook,	.0019
Pittsfield, Hathaway Brook,	.0020

TABLE No. 9. — *Free Ammonia in Surface Waters* — Continued.

[Parts per 100,000.]

Metropolitan Water District, Nashua River,	.0021
Metropolitan Water District, Ashland Reservoir,	.0021
Amherst, Amethyst Brook Reservoir,	.0021
Northbridge, Cook Allen Reservoir,	.0021
Taunton, Assawompsett Pond,	.0021
Abington, Big Sandy Pond,	.0022
Ipswich, Dow's Brook Reservoir,	.0022
Marlborough, Lake Williams,	.0022
North Andover, Great Pond,	.0022
Worcester, Lower Holden Reservoir,	.0022
Metropolitan Water District, Framingham Reservoir No. 3,	.0023
Rutland, Muschopauge Lake,	.0023
Springfield, Ludlow Canal,	.0023
Stockbridge, Lake Averic,	.0023
Weymouth, Great Pond,	.0023
Pittsfield, Sacket Brook,	.0024
Metropolitan Water District, Chestnut Hill Reservoir,	.0025
Gardner, Crystal Lake,	.0025
Holyoke, Wright and Ashley Pond,	.0025
Southbridge, Hatchet Brook Reservoir,	.0025
Williamstown, Flora Glen Reservoir,	.0025
Worcester, Upper Holden Reservoir,	.0025
Athol, Buckman Brook Reservoir,	.0026
Holyoke, Whiting Street Reservoir,	.0026
South Hadley, Leaping Well Reservoir,	.0027
Hudson, Gates Pond,	.0028
Cambridge, Lower Hobbs Brook Reservoir,	.0029
Northborough, Lower Reservoir,	.0029
Metropolitan Water District, Lake Cochituate,	.0030
Cambridge, Stony Brook Reservoir,	.0030
Gloucester, Dike's Brook Reservoir,	.0030
Lynn, tap,	.0030
Worcester, Kent Reservoir,	.0031
Metropolitan Water District, Framingham Reservoir No. 2,	.0032
Metropolitan Water District, Sudbury Reservoir,	.0032
Leominster, Morse Reservoir,	.0032
Westfield, Montgomery Reservoir,	.0032
Metropolitan Water District, Hopkinton Reservoir,	.0033
Metropolitan Water District, Wachusett Reservoir,	.0034
Lynn, Walden Reservoir,	.0034
Lynn, Hawkes Reservoir,	.0034
New Bedford, old storage reservoir,	.0035
Gloucester, Wallace Reservoir,	.0037
Nantucket, Wannacomet Pond,	.0037
Lynn, Breed's Reservoir,	.0039
South Hadley, Buttery Brook Reservoir,	.0039
Winchester, North Reservoir,	.0040
Worcester, Leicester Reservoir,	.0041
Springfield, Ludlow Reservoir,	.0042
Hinsdale, storage reservoir,	.0044
Wakefield, Crystal Lake,	.0044
Wayland, Snake Brook Reservoir,	.0045
Leominster, Haynes Reservoir,	.0047
North Adams, Notch Brook Reservoir,	.0047
Salem, Wenham Lake,	.0047
Athol, Phillipston Reservoir,	.0049
Lynn, Saugus River,	.0050
Lynn, Birch Reservoir,	.0051
Pittsfield, Ashley Brook,	.0052
Cambridge, Fresh Pond,	.0053
Gloucester, Haskell Brook Reservoir,	.0053
Marlborough, Millham Brook Reservoir,	.0054
Winchester, South Reservoir,	.0054
North Brookfield, North Pond,	.0056
Fitchburg, Scott Reservoir,	.0057
Whitman, Hobart's Pond,	.0057

TABLE NO. 9.— *Free Ammonia in Surface Waters* — Concluded.

[Parts per 100,000.]

Springfield, Five Mile Pond,	.0058
Great Barrington, East Mountain Reservoir,	.0059
West Springfield, Darby Brook Reservoir,	.0059
Lynn, Glen Lewis Reservoir,	.0062
Peabody, Spring Pond,	.0062
North Brookfield, Doane Pond,	.0065
Lee, Upper Reservoir on Codding Brook,	.0070
Norwood, Buckmaster Pond,	.0073
Natick, Dug Pond,	.0077
Pittsfield, Ashley Lake,	.0080
Winchester, Middle Reservoir,	.0081
Salem, Longham Reservoir,	.0085
Barre, reservoir,	.0100
Rockport, Cape Pond,	.0114
Lawrence, Merrimack River, filtered,	.0124

TABLE NO. 10.— *Free Ammonia in the Water of Streams.*

[Parts per 100,000.]

Williamstown, Paul Brook,	.0003
Adams, Bassett Brook,	.0005
Chester, Austin Brook,	.0006
Chicopee, Morton Brook,	.0006
Cheshire, Thunder Brook,	.0009
Deerfield, Roaring Brook,	.0009
Northampton, West Brook,	.0009
Easthampton, Bassett Brook,	.0011
Pittsfield, Mill Brook,	.0011
Westfield, Tillotson Brook,	.0011
Great Barrington, Green River,	.0012
Adams, Dry Brook,	.0013
Cheshire, Kitchen Brook,	.0013
Holyoke, Manhan River,	.0014
Lee, Codding Brook,	.0014
Huntington, Cold Brook,	.0015
Longmeadow, Cooley Brook,	.0015
Milford, Charles River, filtered,	.0018
Chicopee, Cooley Brook,	.0019
North Adams, Broad Brook,	.0019
Pittsfield, Hathaway Brook,	.0020
Metropolitan Water District, Nashua River,*	.0021
Springfield, Ludlow Canal,	.0023
Pittsfield, Sacket Brook,	.0024
Lynn, Saugus River,†	.0050
Pittsfield, Ashley Brook,‡	.0052
Lawrence, Merrimack River, filtered,§	.0124

TABLE NO. 11. — *Free Ammonia in the Water of Lakes and Ponds.*

[Parts per 100,000.]

Maynard, White Pond,	.0008
Brockton, Silver Lake,	.0010
Haverhill, Pentucket Lake,	.0010
Hingham, Accord Pond,	.0010
Springfield, Chapin Pond,	.0010
Concord, Sandy Pond,	.0011
Taunton, Elder's Pond,	.0011
Wareham, Jonathan's Pond,	.0011
Haverhill, Johnson's Pond,	.0012
Plymouth, Little South Pond,	.0012
Randolph, Great Pond,	.0012
Fall River, North Watuppa Lake,	.0013
Haverhill, Crystal Lake,	.0013
Haverhill, Kenoza Lake,	.0013

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* Affected by construction of Wachusett Reservoir.

† Free ammonia due to sewage pollution.

‡ This stream is fed largely by water drawn from Ashley Lake.

§ Probably derived in part from the pollution of the river water by sewage and in part from ground water, which enters the filtered water well.

TABLE NO. 11. — *Free Ammonia in the Water of Lakes and Ponds* — Concluded.

[Parts per 100,000.]

Spencer, Shaw Pond,	.0013
Andover, Haggett's Pond,	.0014
Falmouth, Long Pond,	.0014
New Bedford, Little Quittacas Pond,	.0015
Peabody, Brown's Pond,	.0015
Fitchburg, Meetinghouse Pond,	.0016
Danvers, Middleton Pond,	.0017
New Bedford, Great Quittacas Pond,	.0017
Montague, Lake Pleasant,	.0018
Taunton, Assawompsett Pond,	.0021
Abington, Big Sandy Pond,	.0022
Marlborough, Lake Williams,	.0022
North Andover, Great Pond,	.0022
Rutland, Muschopauge Lake,	.0023
Stockbridge, Lake Averic,	.0023
Weymouth, Great Pond,	.0023
Gardner, Crystal Lake,	.0025
Hudson, Gates Pond,	.0028
Metropolitan Water District, Lake Cochituate,	.0030
Nantucket, Wannacomet Pond,	.0037
Wakefield, Crystal Lake,	.0044
Salem, Wenham Lake,	.0047
Cambridge, Fresh Pond,	.0053
Springfield, Five Mile Pond,	.0058
Peabody, Spring Pond,	.0062
Norwood, Buckmaster Pond,	.0073
Natick, Dug Pond,	.0077
Pittsfield, Ashley Lake,	.0080
Rockport, Cape Pond,	.0114

TABLE NO. 12. — *Free Ammonia in the Water of Storage Reservoirs.*

[Parts per 100,000.]

Northfield, reservoir,	.0006
Greenfield, Glen Brook Reservoir,	.0007
Palmer, Lower Reservoir,	.0010
Leominster, Fall Brook Reservoir,	.0013
Northampton, Middle Reservoir,	.0013
Dalton, Egypt Brook Reservoir,	.0014
Lenox, reservoir,	.0015
Hatfield, reservoir,	.0016
Northampton, Mountain Street Reservoir,	.0016
Haverhill, Millvale Reservoir,	.0017
Brockton, Salisbury Brook Reservoir,	.0019
Metropolitan Water District, Ashland Reservoir,	.0021
Amherst, Amethyst Brook Reservoir,	.0021
Northbridge, Cook Allen Reservoir,	.0021
Ipswich, Dow's Brook Reservoir,	.0022
Worcester, Lower Holden Reservoir,	.0022
Metropolitan Water District, Framingham Reservoir No. 3,	.0023
Holyoke, Wright and Ashley Pond,	.0025
Southbridge, Hatchet Brook Reservoir,	.0025
Williamstown, Flora Glen Reservoir,	.0025
Worcester, Upper Holden Reservoir,	.0025
Athol, Buckman Brook Reservoir,	.0026
Holyoke, Whiting Street Reservoir,	.0026
South Hadley, Leaping Well Reservoir,	.0027
Cambridge, Lower Hobbs Brook Reservoir,	.0029
Northbridge, Lower Reservoir,	.0029
Cambridge, Stony Brook Reservoir,	.0030
Gloucester, Dike's Brook Reservoir,	.0030
Worcester, Kent Reservoir,	.0031
Metropolitan Water District, Framingham Reservoir No. 2,	.0032
Metropolitan Water District, Sudbury Reservoir,	.0032
Leominster, Morse Reservoir,	.0032
Westfield, Montgomery Reservoir,	.0032
Metropolitan Water District, Hopkinton Reservoir,	.0033
Metropolitan Water District, Wachusett Reservoir,	.0034
Lynn, Walden Reservoir,	.0034

Table No. 12. — *Free Ammonia in the Water of Storage Reservoirs* — Concluded.

[Parts per 100,000.]

Lynn, Hawkes Reservoir,	.0034
New Bedford, old storage reservoir,	.0035
Gloucester, Wallace Reservoir,	.0037
Lynn, Breed's Reservoir,	.0039
South Hadley, Buttery Brook Reservoir,	.0039
Winchester, North Reservoir,	.0040
Worcester, Leicester Reservoir,	.0041
Springfield, Ludlow Reservoir,	.0042
Hinsdale, storage reservoir,	.0044
Wayland, Snake Brook Reservoir,	.0045
Leominster, Haynes Reservoir,	.0047
North Adams, Notch Brook Reservoir,	.0047
Athol, Phillipston Reservoir,	.0049
Lynn, Birch Reservoir,	.0051
Gloucester, Haskell Brook Reservoir,	.0053
Marlborough, Millham Brook Reservoir,	.0054
Winchester, South Reservoir,	.0054
North Brookfield, North Pond,	.0056
Fitchburg, Scott Reservoir,	.0057
Whitman, Hobart's Pond,	.0057
Great Barrington, East Mountain Reservoir,	.0059
West Springfield, Darby Brook Reservoir,	.0059
Lynn, Glen Lewis Reservoir,	.0062
North Brookfield, Doane Pond,	.0065
Lee, Upper Reservoir on Codding Brook,	.0070
Winchester, Middle Reservoir,	.0081
Salem, Longham Reservoir,	.0085
Barre, reservoir,	.0100

ODORS OF SURFACE WATERS.

Practically all surface waters have at times a noticeable odor. The odors of the waters of unpolluted streams derived from a country for the most part free from swamps are generally slight, and where such waters are passed through a reservoir of small capacity in proportion to the flow of the stream they may be nearly always odorless. Waters derived from swampy areas usually have a noticeably vegetable odor. The waters of nearly all ponds and storage reservoirs are affected at times by growths of organisms which give to the water noticeable tastes and odors, which are sometimes unpleasant or disagreeable. The waters of some ponds are affected in this way only slightly and at infrequent intervals. In other cases the waters are affected at certain seasons of the year, though not in every year, while in a few cases the waters are affected in every year in a more or less serious degree. Some of the waters are so badly affected by disagreeable taste and odor that they are at times unfit for domestic use.

In the following table the waters of the various sources are grouped in accordance with the frequency and intensity of the odors which have been recorded from the observations of the past five years. For convenience, the groups have been divided so as to show the comparative odors of the waters of streams, ponds and artificial storage reservoirs.

TABLE NO. 13. — *Odors of Surface Waters.*

GROUP I. — *Waters which are Odorless or which have Occasional Faint Odors.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Adams,	Bassett Brook.	Milford,	Charles River, filtered.
Adams,	Dry Brook.	North Adams,	Broad Brook.
Brockton,	Silver Lake.	North Adams,	Notch Brook Reservoir.
Cheshire,	Kitchen Brook.	Northampton,	Mountain Street Reservoir.
Cheshire,	Thunder Brook.	Northampton,	West Brook.
Chester,	Austin Brook.	Northfield,	Reservoir.
Chicopee,	Morton Brook.	Pittsfield,	Ashley Brook.
Dalton,	Egypt Brook Reservoir.	Pittsfield,	Hathaway Brook.
Deerfield,	Roaring Brook.	Pittsfield,	Mill Brook.
Easthampton,	Bassett Brook.	Pittsfield,	Sacket Brook.
Falmouth,	Long Pond.	Rutland,	Muschopauge Lake.
Great Barrington,	East Mountain Reservoir.	Spencer,	Shaw Pond.
Great Barrington,	Green River.	Westfield,	Tillotson Brook.
Greenfield,	Glen Brook Reservoir.	Williamstown,	Flora Glen Reservoir.
Huntington,	Cold Brook.	Williamstown,	Paul Brook.
Lee,	Codding Brook.	Worcester,	Lower Holden Reservoir.
Longmeadow,	Cooley Brook.		

GROUP II. — *Waters which are usually Odorless but have occasionally a Distinct and at Times an Unpleasant Odor.*

Metropolitan Water District.	Nashua River.	Holyoke,	Manhan River.
Metropolitan Water District.	Sudbury Reservoir.	Hudson,	Gates Pond.
Amherst,	Amethyst Brook Reservoir.	Lee,	Upper Reservoir on Codding Brook.
Andover,	Haggett's Pond.	Lenox,	Reservoir.
Athol,	Buckman Brook Reservoir.	Lynn,	Hawkes Reservoir.
Barre,	Reservoir.	Maynard,	White Pond.
Chicopee,	Cooley Brook.	Montague,	Lake Pleasant.
Concord,	Sandy Pond.	New Bedford,	Little Quittacas Pond.
Fall River,	North Watuppa Lake.	Northampton,	Middle Reservoir.
Fitchburg,	Meetinghouse Pond.	North Andover,	Great Pond.
Gardner,	Crystal Lake.	Northbridge,	Cook Allen Reservoir.
Hatfield,	Reservoir.	Palmer,	Lower Reservoir.
Haverhill,	Crystal Lake.	Pittsfield,	Ashley Lake.
Haverhill,	Johnson's Pond.	Plymouth,	Little South Pond.
Haverhill,	Pentucket Lake.	Randolph,	Great Pond.
Hingham,	Accord Pond.	Southbridge,	Hatchet Brook Reservoir.

TABLE NO. 13.— *Odors of Surface Waters* — Continued.

GROUP II.— *Waters which are usually Odorless but have occasionally a Distinct and at Times an Unpleasant Odor* — Concluded.

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
South Hadley,	Leaping Well Reservoir.	Westfield,	Montgomery Reservoir.
Taunton,	Elder's Pond.	Worcester,	Kent Reservoir.
Taunton,	Assawompsett Pond.	Worcester,	Upper Holden Reservoir.
Wareham,	Jonathan's Pond.	Worcester,	Leicester Reservoir.

GROUP III.— *Waters which have frequently a Noticeable and at Times a Distinct or Unpleasant Odor.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Metropolitan Water District.	Wachusett Reservoir.	Lawrence,	Merrimack River, filtered.
Metropolitan Water District.	Lake Cochituate.	Leominster,	Fall Brook Reservoir.
Metropolitan Water District.	Framingham Reservoir No. 2.	Leominster,	Morse Reservoir.
Metropolitan Water District.	Framingham Reservoir No. 3.	New Bedford,	Great Quittacas Pond.
Metropolitan Water District.	Ashland Reservoir.	North Brookfield,	North Pond.
Metropolitan Water District.	Hopkinton Reservoir.	Norwood,	Buckmaster Pond.
Abington,	Big Sandy Pond.	Peabody,	Brown's Pond.
Cambridge,	Lower Hobbs Brook Reservoir.	Peabody,	Spring Pond.
Danvers,	Middleton Pond.	Salem,	Wenham Lake.
Fitchburg,	Scott Reservoir.	South Hadley,	Buttery Brook Reservoir.
Gloucester,	Haskell Brook Reservoir.	Springfield,	Five Mile Pond.
Haverhill,	Millvale Reservoir.	Springfield,	Chapin Pond.
Haverhill,	Kenoza Lake.	Stockbridge,	Lake Averic.
Holyoke,	Wright and Ashley Pond.	Wakefield,	Crystal Lake.
Ipswich,	Dow's Brook Reservoir.	Weymouth,	Great Pond.

GROUP IV.— *Waters which have generally a Noticeable Odor which is frequently Unpleasant or Disagreeable.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Brockton,	Salisbury Brook Reservoir.	Marlborough,	Millham Brook Reservoir.
Cambridge,	Fresh Pond.	Nantucket,	Wannacomet Pond.
Cambridge,	Stony Brook Reservoir.	Natick,	Dug Pond.
Gloucester,	Wallace Reservoir.	New Bedford,	Old storage reservoir.
Gloucester,	Dike's Brook Reservoir.	Northborough,	Lower Reservoir.
Holyoke,	Whiting Street Reservoir.	North Brookfield,	Doane Pond.
Leominster,	Haynes Reservoir.	Rockport,	Cape Pond.
Lynn,	Birch Reservoir.	Wayland,	Snake Brook Reservoir.
Lynn,	Breed's Reservoir.	Winchester,	North Reservoir.
Lynn,	Saugus River.	Winchester,	South Reservoir.
Marlborough,	Lake Williams.		

TABLE No. 13. — *Odors of Surface Waters* — Concluded.

GROUP V. — *Waters which have generally a Strong and frequently an Unpleasant or Disagreeable Odor.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Athol, ...	Phillipston Reservoir.	Springfield, . . .	Ludlow Reservoir.
Hinsdale, . . .	Storage Reservoir.	Springfield, . . .	Ludlow Canal.
Lynn, ...	Walden Reservoir.	West Springfield, .	Darby Brook Reservoir.
Lynn, ...	Glen Lewis Reservoir.	Whitman, . . .	Hobart's Pond.
Salem, ...	Longham Reservoir.	Winchester, . .	Middle Reservoir.

TABLE No. 14. — *Odors of the Water of Streams.*

GROUP I. — *Waters which are Odorless or which have Occasional Faint Odors.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Adams, . . .	Bassett Brook.	Longmeadow, . .	Cooley Brook.
Adams, . . .	Dry Brook.	Milford, . . .	Charles River, filtered.
Cheshire, . . .	Kitchen Brook.	North Adams, . .	Broad Brook.
Cheshire, . . .	Thunder Brook.	Northampton, . .	West Brook.
Chester, . . .	Austin Brook.	Pittsfield, . . .	Ashley Brook.
Chicopee, . . .	Morton Brook.	Pittsfield, . . .	Hathaway Brook.
Deerfield, . . .	Roaring Brook.	Pittsfield, . . .	Mill Brook.
Easthampton, . .	Bassett Brook.	Pittsfield, . . .	Sacket Brook.
Great Barrington, .	Green River.	Westfield, . . .	Tillotson Brook.
Huntington, . .	Cold Brook.	Williamstown, . .	Paul Brook.
Lee, ...	Codding Brook.		

GROUP II. — *Waters which are usually Odorless but have occasionally a Distinct and at Times an Unpleasant Odor.*

Metropolitan Water District.	Nashua River.	Holyoke, . . .	Manhan River.
Chicopee, . . .	Cooley Brook.		

GROUP III. — *Waters which have frequently a Noticeable and at Times a Distinct or Unpleasant Odor.*

Lawrence, . . .	Merrimack River, filtered.	-	-

GROUP IV. — *Waters which have generally a Noticeable Odor which is frequently Unpleasant or Disagreeable.*

Lynn, ...	Saugus River.	-	-

TABLE NO. 14. — *Odors of the Water of Streams* — Concluded.

GROUP V. — *Waters which have generally a Strong and frequently an Unpleasant or Disagreeable Odor.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Springfield, . . .	Ludlow Canal.	–	–

TABLE NO. 15. — *Odors of the Water of Lakes and Ponds.*

GROUP I. — *Waters which are Odorless or which have Occasional Faint Odors.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Brockton, . . .	Silver Lake.	Rutland, . . .	Muschopauge Lake.
Falmouth, . . .	Long Pond.	Spencer, . . .	Shaw Pond.

GROUP II. — *Waters which are usually Odorless, but have occasionally a Distinct and at Times an Unpleasant Odor.*

Andover, . . .	Haggett's Pond.	Maynard, . . .	White Pond.
Concord, . . .	Sandy Pond.	Montague, . . .	Lake Pleasant.
Fall River, . . .	North Watuppa Lake.	New Bedford, . .	Little Quittacas Pond.
Fitchburg, . . .	Meetinghouse Pond.	North Andover, . .	Great Pond.
Gardner, . . .	Crystal Lake.	Pittsfield, . . .	Ashley Lake.
Haverhill, . . .	Crystal Lake.	Plymouth, . . .	Little South Pond.
Haverhill, . . .	Johnson's Pond.	Randolph, . . .	Great Pond.
Haverhill, . . .	Pentucket Lake.	Taunton, . . .	Elder's Pond.
Hingham, . . .	Accord Pond.	Taunton, . . .	Assawompsett Pond.
Hudson, . . .	Gates Pond.	Wareham, . . .	Jonathan's Pond.

GROUP III. — *Waters which have frequently a Noticeable and at Times a Distinct or Unpleasant Odor.*

Metropolitan Water District.	Lake Cochituate.	Peabody, . . .	Spring Pond.
Abington, . . .	Big Sandy Pond.	Salem, ...	Wenham Lake.
Danvers, . . .	Middleton Pond.	Springfield, . . .	Five Mile Pond.
Haverhill, . . .	Kenoza Lake.	Springfield, . . .	Chapin Pond.
New Bedford, . .	Great Quittacas Pond.	Stockbridge, . .	Lake Averic.
Norwood, . . .	Buckmaster Pond.	Wakefield, . . .	Crystal Lake.
Peabody, . . .	Brown's Pond.	Weymouth, . . .	Great Pond.

TABLE No. 15. — *Odors of the Water of Lakes and Ponds* — Concluded.

GROUP IV. — *Waters which have generally a Noticeable Odor which is frequently Unpleasant or Disagreeable.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Cambridge, . . .	Fresh Pond.	Natick, ...	Dug Pond.
Marlborough, . .	Lake Williams.	Rockport, . . .	Cape Pond.
Nantucket, . . .	Wannacomet Pond.		

TABLE No. 16. — *Odors of the Water of Storage Reservoirs.*

GROUP I. — *Waters which are Odorless or which have Occasional Faint Odors.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Dalton, ...	Egypt Brook Reservoir.	Northampton, . .	Mountain Street Reservoir.
Great Barrington, .	East Mountain Reservoir.	Northfield, . . .	Reservoir.
Greenfield, . . .	Glen Brook Reservoir.	Williamstown, . .	Flora Glen Reservoir.
North Adams, . .	Notch Brook Reservoir.	Worcester, . . .	Lower Holden Reservoir.

GROUP II. — *Waters which are Usually Odorless but have occasionally a Distinct and at Times an Unpleasant Odor.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Metropolitan Water District.	Sudbury Reservoir.	Northbridge, . .	Cook Allen Reservoir.
Amherst, ...	Amethyst Brook Reservoir.	Palmer, . . .	Lower Reservoir.
Athol, ...	Buckman Brook Reservoir.	Southbridge, . .	Hatchet Brook Reservoir.
Barre, ...	Reservoir.	South Hadley, . .	Leaping Well Reservoir.
Hatfield. . . .	Reservoir.	Westfield, . . .	Montgomery Reservoir.
Lee, ...	Upper Reservoir on Codding Brook.	Worcester, . . .	Kent Reservoir.
Lenox, ...	Reservoir.	Worcester, . . .	Upper Holden Reservoir.
Lynn, ...	Hawkes Reservoir.	Worcester, . . .	Leicester Reservoir.
Northampton, . .	Middle Reservoir.		

GROUP III. — *Waters which have frequently a Noticeable and at times a Distinct or Unpleasant Odor.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Metropolitan Water District.	Wachusett Reservoir.	Haverhill, . . .	Millvale Reservoir.
Metropolitan Water District.	Framingham Reservoir No. 2.	Holyoke, . . .	Wright and Ashley Pond.
Metropolitan Water District.	Framingham Reservoir No. 3.	Ipswich, . . .	Dow's Brook Reservoir.
Metropolitan Water District.	Ashland Reservoir.	Leominster, . .	Fall Brook Reservoir.
Metropolitan Water District.	Hopkinton Reservoir.	Leominster, . .	Morse Reservoir.
Cambridge, . . .	Lower Hobbs Brook Reservoir.	North Brookfield, .	North Pond.
Fitchburg, . . .	Scott Reservoir.	South Hadley, . .	Buttery Brook Reservoir.
Gloucester, . . .	Haskell Brook Reservoir.		

TABLE No. 16. — *Odors of the Water of Storage Reservoirs* — Concluded.

GROUP IV. — *Waters which have generally a Noticeable Odor which is frequently Unpleasant or Disagreeable.*

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Brockton,	Salisbury Brook Reservoir.	Marlborough,	Millham Brook Reservoir.
Cambridge,	Stony Brook Reservoir.	New Bedford,	Old Storage Reservoir.
Gloucester,	Wallace Reservoir.	Northborough,	Lower Reservoir.
Gloucester,	Dike's Brook Reservoir.	North Brookfield,	Doane Pond.
Holyoke,	Whiting Street Reservoir.	Wayland,	Snake Brook Reservoir.
Leominster,	Haynes Reservoir.	Winchester,	North Reservoir.
Lynn,	Birch Reservoir.	Winchester,	South Reservoir.
Lynn,	Breed's Reservoir.		

GROUP V. — *Waters which have generally a Strong and frequently an Unpleasant or Disagreeable Odor.*

Athol,	Phillipston Reservoir.	Springfield,	Ludlow Reservoir.
Hinsdale,	Storage Reservoir.	West Springfield,	Darby Brook Reservoir.
Lynn,	Walden Reservoir.	Whitman,	Hobart's Pond.
Lynn,	Glen Lewis Reservoir.	Winchester,	Middle Reservoir.
Salem,	Longham Reservoir.		

COLOR OF SURFACE WATERS.

The contact of surface waters with vegetation enables them to take up coloring matter from the leaves, grasses, peat, etc., and long contact with vegetable matter in swamps imparts to some of the waters a very high color. Practically all of the surface waters used as sources of water supply in the State are more or less colored by vegetable matter. Waters derived from steep water-sheds, such as those of the mountain streams in the westerly part of the State, are for the most part nearly colorless, as are also the waters of streams which are fed largely by springs. The waters of some ponds and reservoirs, though receiving through their tributary streams waters having a high color, are nearly colorless, the color having been removed from the water by bleaching chiefly, due to exposure to sunlight for a long period.

The following table, No. 17, gives the average color of the various water supplies in the State in the last five years; and for convenience, this table has also been divided so as to show the comparative color of the waters of streams, natural ponds and storage reservoirs (Tables 18–20).

TABLE NO. 17.— *Color of Surface Waters.*

[Parts per 100,000.]

Falmouth, Long Pond,	0.00
Cheshire, Thunder Brook,	0.01
Cheshire, Kitchen Brook,	0.01
Great Barrington, Green River,	0.01
Plymouth, Little South Pond,	0.01
Adams, Bassett Brook,	0.02
Chicopee, Morton Brook,	0.02
Concord, Sandy Pond,	0.02
Greenfield, Glen Brook Reservoir,	0.02
Montague, Lake Pleasant,	0.02
Wareham, Jonathan's Pond,	0.02
Williamstown, Paul Brook,	0.02
Deerfield, Roaring Brook,	0.03
North Adams, Notch Brook Reservoir,	0.03
Peabody, Spring Pond,	0.03
Pittsfield, Mill Brook,	0.03
South Hadley, Leaping Well Reservoir,	0.03
Spencer, Shaw Pond,	0.03
Haverhill, Pentucket Lake,	0.04
Maynard, White Pond,	0.04
Northampton, Mountain Street Reservoir,	0.04
Springfield, Chapin Pond,	0.04
Gardner, Crystal Lake,	0.05
Lenox, reservoir,	0.05
Pittsfield, Hathaway Brook,	0.05
Rutland, Muschopauge Lake,	0.05
Taunton, Elder's Pond,	0.05
Fitchburg, Meetinghouse Pond,	0.06
Longmeadow, Cooley Brook,	0.06
Metropolitan Water District, Spot Pond,	0.07
Barre, reservoir,	0.07
Chester, Austin Brook,	0.07
Nantucket, Wannacomet Pond,	0.07
Pittsfield, Sacket Brook,	0.07
Springfield, Five Mile Pond,	0.07
Williamstown, Flora Glen Reservoir,	0.07
Worcester, Lower Holden Reservoir,	0.07
Holyoke, Whiting Street Reservoir,	0.08
Hudson, Gates Pond,	0.08
Marlborough, Lake Williams,	0.08
Westfield, Tillotson Brook,	0.08
Winchester, North Reservoir,	0.08
Brockton, Silver Lake,	0.09
Haverhill, Kenoza Lake,	0.09
Holyoke, Wright and Ashley Pond,	0.09
Stockbridge, Lake Averic,	0.09
Winchester, South Reservoir,	0.09
Haverhill, Johnson's Pond,	0.10
Norwood, Buckmaster Pond,	0.10
Metropolitan Water District, tap in Revere,	0.11
Abington, Big Sandy Pond,	0.11
Hatfield, reservoir,	0.11
Leominster, Fall Brook Reservoir,	0.11
Great Barrington, East Mountain Reservoir,	0.12
North Andover, Great Pond,	0.12
Salem, Wenham Lake,	0.12
Andover, Haggett's Pond,	0.13
Cambridge, Lower Hobbs Brook Reservoir,	0.13
Natick, Dug Pond,	0.13
Northampton, West Brook,	0.13
Pittsfield, Ashley Brook,	0.14
West Springfield, Darby Brook Reservoir,	0.14
Worcester, Upper Holden Reservoir,	0.14
Fall River, North Watuppa Lake,	0.15
Peabody, Brown's Pond,	0.15
Fitchburg, Scott Reservoir,	0.16
Haverhill, Crystal Lake,	0.16
North Adams, Broad Brook,	0.16
Northfield, reservoir,	0.16
Wakefield, Crystal Lake,	0.16
Adams, Dry Brook,	0.17
Huntington, Cold Brook,	0.17
Leominster, Haynes Reservoir,	0.17
South Hadley, Buttery Brook Reservoir,	0.17
Cambridge, Fresh Pond,	0.18

TABLE NO. 17. — *Color of Surface Waters* — Concluded.

[Parts per 100,000.]

Lee, Codding Brook,	0.18
Easthampton, Bassett Brook,	0.19
Hingham, Accord Pond,	0.19
Leominster, Morse Reservoir,	0.19
Metropolitan Water District, Wachusett Reservoir,	0.20
Hinsdale, storage reservoir,	0.20
Milford, Charles River, filtered,	0.20
Winchester, Middle Reservoir,	0.20
Northampton, Middle Reservoir,	0.21
Metropolitan Water District, Framingam Reservoir No. 3,	0.22
Metropolitan Water District, Lake Cochituate,	0.22
New Bedford, tap in City Hall,	0.22
Metropolitan Water District, tap in Quincy,	0.23
Worcester, Leicester Reservoir,	0.23
Metropolitan Water District, Sudbury Reservoir,	0.24
Metropolitan Water District, tap in State House,	0.24
Ipswich, Dow's Brook Reservoir,	0.24
Dalton, Egypt Brook Reservoir,	0.25
Lynn, Glen Lewis Reservoir,	0.25
New Bedford, Little Quittacas Pond,	0.25
Taunton, Assawompsett Pond,	0.26
Metropolitan Water District, Chestnut Hill Reservoir,	0.27
Northbridge, Cook Allen Reservoir,	0.27
Palmer, Lower Reservoir,	0.27
Rockport, Cape Pond,	0.27
Springfield, Ludlow Reservoir,	0.27
Worcester, Kent Reservoir,	0.29
Pittsfield, Ashley Lake,	0.31
Holyoke, Manhan River,	0.32
Metropolitan Water District, Nashua River,	0.34
Gloucester, Dike's Brook Reservoir,	0.34
Lawrence, Merrimack River, filtered,	0.34
Lynn, Birch Reservoir,	0.34
Lee, Upper Reservoir on Codding Brook,	0.35
Southbridge, Hatchet Brook Reservoir,	0.35
Lynn, Breed's Reservoir,	0.36
Lynn, tap,	0.36
Gloucester, Wallace Reservoir,	0.37
Springfield, Ludlow Canal,	0.37
Athol, Buckman Brook Reservoir,	0.38
Lynn, Hawkes Reservoir,	0.38
Amherst, Amethyst Brook Reservoir,	0.39
Lynn, Walden Reservoir,	0.39
Cambridge, Stony Brook Reservoir,	0.40
Randolph, Great Pond,	0.40
New Bedford, Great Quittacas Pond,	0.43
Gloucester, Haskell Brook Reservoir,	0.45
Marlborough, Millham Brook Reservoir,	0.46
Westfield, Montgomery Reservoir,	0.48
Metropolitan Water District, Hopkinton Reservoir,	0.51
Haverhill, Millvale Reservoir,	0.52
North Brookfield, North Pond,	0.52
North Brookfield, Doane Pond,	0.53
Danvers, Middleton Pond,	0.54
Metropolitan Water District, Ashland Reservoir,	0.55
Brockton, Salisbury Brook Reservoir,	0.55
Chicopee, Cooley Brook,	0.59
Whitman, Hobart's Pond,	0.60
Northborough, Lower Reservoir,	0.61
Athol, Phillipston Reservoir,	0.62
Metropolitan Water District, Framingham Reservoir No. 2,	0.69
Weymouth, Great Pond,	0.69
Wayland, Snake Brook Reservoir,	0.80
Lynn, Saugus River,	0.86
Salem, Longham Reservoir,	0.94
New Bedford, old storage reservoir,	1.00

TABLE NO. 18.— *Color of the Water of Streams.*

[Parts per 100,000.]

Cheshire, Thunder Brook,	.01
Cheshire, Kitchen Brook,	.01
Great Barrington, Green River,	.01
Adams, Bassett Brook,	.02
Chicopee, Morton Brook,	.02
Williamstown, Paul Brook,	.02
Deerfield, Roaring Brook,	.03
Pittsfield, Mill Brook,	.03
Pittsfield, Hathaway Brook,	.05
Longmeadow, Cooley Brook,	.06
Chester, Austin Brook,	.07
Pittsfield, Sacket Brook,	.07
Westfield, Tillotson Brook,	.08
Northampton, West Brook,	.13
Pittsfield, Ashley Brook,	.14
North Adams, Broad Brook,	.16
Adams, Dry Brook,	.17
Huntington, Cold Brook,	.17
Lee, Codding Brook,	.18
Easthampton, Bassett Brook,	.19
Milford, Charles River, filtered,	.20
Holyoke, Manhan River,	.32
Metropolitan Water District, Nashua River,	.34
Lawrence, Merrimack River, filtered,	.34
Springfield, Ludlow Canal,	.37
Chicopee, Cooley Brook,	.59
Lynn, Saugus River,	.86

TABLE NO. 19.— *Color of the Water of Lakes and Ponds.*

[Parts per 100,000.]

Falmouth, Long Pond,	.00
Plymouth, Little South Pond,	.01
Concord, Sandy Pond,	.02
Montague, Lake Pleasant,	.02
Wareham, Jonathan's Pond,	.02
Peabody, Spring Pond,	.03
Spencer, Shaw Pond,	.03
Haverhill, Pentucket Lake,	.04
Maynard, White Pond,	.04
Springfield, Chapin Pond,	.04
Gardner, Crystal Lake,	.05
Rutland, Muschopauge Lake,	.05
Taunton, Elder's Pond,	.05
Fitchburg, Meetinghouse Pond,	.06
Nantucket, Wannacomet Pond,	.07
Springfield, Five Mile Pond,	.07
Hudson, Gates Pond,	.08
Marlborough, Lake Williams,	.08
Brockton, Silver Lake,	.09
Haverhill, Kenoza Lake,	.09
Stockbridge, Lake Averic,	.09
Haverhill, Johnson's Pond,	.10
Norwood, Buckmaster Pond,	.10
Abington, Big Sandy Pond,	.11
North Andover, Great Pond,	.12
Salem, Wenham Lake,	.12
Andover, Haggett's Pond,	.13
Natick, Dug Pond,	.13
Fall River, North Watuppa Lake,	.15
Peabody, Brown's Pond,	.15
Haverhill, Crystal Lake,	.16
Wakefield, Crystal Lake,	.16
Cambridge, Fresh Pond,	.18
Hingham, Accord Pond,	.19
Metropolitan Water District, Lake Cochituate,	.22
New Bedford, Little Quittacas Pond,	.25
Taunton, Assawompsett Pond,	.26
Rockport, Cape Pond,	.27
Pittsfield, Ashley Lake,	.31
Randolph, Great Pond,	.40
New Bedford, Great Quittacas Pond,	.43
Danvers, Middleton Pond,	.54
Weymouth, Great Pond,	.69

TABLE NO. 20. — *Color of the Water of Storage Reservoirs.*

[Parts per 100,000.]

Greenfield, Glen Brook Reservoir,	0.02
North Adams, Notch Brook Reservoir,	0.03
South Hadley, Leaping Well Reservoir,	0.03
Northampton, Mountain Street Reservoir,	0.04
Lenox, reservoir,	0.05
Barre, reservoir,	0.07
Williamstown, Flora Glen Reservoir,	0.07
Worcester, Lower Holden Reservoir,	0.07
Holyoke, Whiting Street Reservoir,	0.08
Winchester, North Reservoir,	0.08
Holyoke, Wright and Ashley Pond,	0.09
Winchester, South Reservoir,	0.09
Hatfield, reservoir,	0.11
Leominster, Fall Brook Reservoir,	0.11
Great Barrington, East Mountain Reservoir,	0.12
Cambridge, Lower Hobbs Brook Reservoir,	0.13
West Springfield, Darby Brook Reservoir,	0.14
Worcester, Upper Holden Reservoir,	0.14
Fitchburg, Scott Reservoir,	0.16
Northfield, reservoir,	0.16
Leominster, Haynes Reservoir,	0.17
South Hadley, Buttery Brook Reservoir,	0.17
Leominster, Morse Reservoir,	0.19
Metropolitan Water District, Wachusett Reservoir,	0.20
Hinsdale, storage reservoir,	0.20
Winchester, Middle Reservoir,	0.20
Northampton, Middle Reservoir,	0.21
Metropolitan Water District, Framingham Reservoir No. 3,	0.22
Worcester, Leicester Reservoir,	0.23
Metropolitan Water District, Sudbury Reservoir,	0.24
Ipswich, Dow's Brook Reservoir,	0.24
Dalton, Egypt Brook Reservoir,	0.25
Lynn, Glen Lewis Reservoir,	0.25
Northbridge, Cook Allen Reservoir,	0.27
Palmer, Lower Reservoir,	0.27
Springfield, Ludlow Reservoir,	0.27
Worcester, Kent Reservoir,	0.29
Gloucester, Dike's Brook Reservoir,	0.34
Lynn, Birch Reservoir,	0.34
Lee, Upper Reservoir on Codding Brook,	0.35
Southbridge, Hatchet Brook Reservoir,	0.35
Lynn, Breed's Reservoir,	0.36
Gloucester, Wallace Reservoir,	0.37
Athol, Buckman Brook Reservoir,	0.38
Lynn, Hawkes Reservoir,	0.38
Amherst, Amethyst Brook Reservoir,	0.39
Lynn, Walden Reservoir,	0.39
Cambridge, Stony Brook Reservoir,	0.40
Gloucester, Haskell Brook Reservoir,	0.45
Marlborough, Millham Brook Reservoir,	0.46
Westfield, Montgomery Reservoir,	0.48
Metropolitan Water District, Hopkinton Reservoir,	0.51
Haverhill, Millvale Reservoir,	0.52
North Brookfield, North Pond,	0.52
North Brookfield, Doane Pond,	0.53
Metropolitan Water District, Ashland Reservoir,	0.55
Brockton, Salisbury Brook Reservoir,	0.55
Whitman, Hobart's Pond,	0.60
Northborough, Lower Reservoir,	0.61
Athol, Phillipston Reservoir,	0.62
Metropolitan Water District, Framingham Reservoir No. 2,	0.69
Wayland, Snake Brook Reservoir,	0.80
Salem, Longham Reservoir,	0.94
New Bedford, old storage reservoir,	1.00

HARDNESS OF SURFACE WATERS.

The normal waters in most parts of Massachusetts are soft. The waters which have the greatest hardness are those of the limestone regions, located chiefly in the westerly part of the State, and those derived from populous districts.

The following table gives the hardness of the various sources of water supply used in the State. It will be seen from this table that the waters having the highest hardness are all located in Berkshire County, the only waters in the eastern part of the State having a hardness in excess of 2.5 parts per 100,000 being Fresh Pond, the water supply of Cambridge, and the Saugus River, used as a source of water supply of Lynn. Fresh Pond has probably been affected somewhat by sea water, and considerably by the large population living in its neighborhood; while the hardness of the Saugus River water is caused by pollution from the very large population within its water-shed.

TABLE NO. 21. — *Hardness of Surface Waters.*

[Parts per 100,000.]

Leominster, Morse Reservoir,	0.1
Leominster, Haynes Reservoir,	0.1
Plymouth, Little South Pond,	0.1
Wareham, Jonathan's Pond,	0.1
Falmouth, Long Pond,	0.2
Hinsdale, storage reservoir,	0.2
Leominster, Fall Brook Reservoir,	0.2
Fitchburg, Scott Reservoir,	0.3
Gloucester, Dike's Brook Reservoir,	0.3
Hingham, Accord Pond,	0.3
Westfield, Montgomery Reservoir,	0.3
Worcester, Upper Holden Reservoir,	0.3
Amherst, Amethyst Brook Reservoir,	0.4
Brockton, Silver Lake,	0.4
Concord, Sandy Pond,	0.4
Gloucester, Wallace Reservoir,	0.4
Gloucester, Haskell Brook Reservoir,	0.4
Lee, Upper Reservoir on Codding Brook,	0.4
Lynn, Glen Lewis Reservoir,	0.4
Montague, Lake Pleasant,	0.4
Northbridge, Cook Allen Reservoir,	0.4
Rutland, Muschopauge Lake,	0.4
Springfield, Chapin Pond,	0.4
Springfield, Five Mile Pond,	0.4
Taunton, Elder's Pond,	0.4
Abington, Big Sandy Pond,	0.5
Fitchburg, Meetinghouse Pond,	0.5
North Brookfield, Doane Pond,	0.5
North Brookfield, North Pond,	0.5
South Hadley, Leaping Well Reservoir,	0.5
Taunton, Assawompsett Pond,	0.5
Westfield, Tillotson Brook,	0.5
Weymouth, Great Pond,	0.5
Athol, Phillipston Reservoir,	0.6
Brockton, Salisbury Brook Reservoir,	0.6
Fall River, North Watuppa Lake,	0.6
Hudson, Gates Pond,	0.6
Maynard, White Pond,	0.6
New Bedford, Little Quittacas Pond,	0.6
New Bedford, Great Quittacas Pond,	0.6
Palmer, Lower Reservoir,	0.6
Peabody, Brown's Pond,	0.6
Southbridge, Hatchet Brook Reservoir,	0.6
Worcester, Lower Holden Reservoir,	0.6
Athol, Buckman Brook Reservoir,	0.7
Chicopee, Morton Brook,	0.7
Lynn, Walden Reservoir,	0.7
New Bedford, tap in City Hall,	0.7

TABLE NO 21. — *Hardness of Surface Waters* — Continued.

[Parts per 100,000.]

Northfield, reservoir,	0.7
Norwood, Buckmaster Pond,	0.7
Spencer, Shaw Pond,	0.7
Springfield, Ludlow Reservoir,	0.7
Metropolitan Water District, Ashland Reservoir,	0.8
Metropolitan Water District, Hopkinton Reservoir,	0.8
Dalton, Egypt Brook Reservoir,	0.8
Lynn, Breed's Reservoir,	0.8
Worcester, Leicester Reservoir,	0.8
Metropolitan Water District, Nashua River,	0.9
Metropolitan Water District, Wachusett Reservoir,	0.9
Chicopee, Cooley Brook,	0.9
Haverhill, Crystal Lake,	0.9
New Bedford, old storage reservoir,	0.9
Northborough, Lower Reservoir,	0.9
South Hadley, Buttery Brook Reservoir,	0.9
Worcester, Kent Reservoir,	0.9
Metropolitan Water District, Framingham Reservoir No. 2,	1.0
Huntington, Cold Brook,	1.0
Randolph, Great Pond,	1.0
Springfield, Ludlow Canal,	1.0
Lynn, Birch Reservoir,	1.1
Milford, Charles River, filtered,	1.1
Winchester, Middle Reservoir,	1.1
Metropolitan Water District, Sudbury Reservoir,	1.2
Andover, Haggett's Pond,	1.2
Barre, reservoir,	1.2
Danvers, Middleton Pond,	1.2
Easthampton, Bassett Brook,	1.2
Lynn, tap,	1.2
North Andover, Great Pond,	1.2
Winchester, South Reservoir,	1.2
Metropolitan Water District, Framingham Reservoir No. 3,	1.3
Metropolitan Water District, Chestnut Hill Reservoir,	1.3
Gardner, Crystal Lake,	1.3
Marlborough, Millham Brook Reservoir,	1.3
Rockport, Cape Pond,	1.3
Wayland, Snake Brook Reservoir,	1.3
Chester, Austin Brook,	1.4
Holyoke, Manhan River,	1.4
Lynn, Hawkes Reservoir,	1.4
Metropolitan Water District, tap in State House,	1.5
Nantucket, Wannacomet Pond,	1.5
Northampton, Middle Reservoir,	1.5
Peabody, Spring Pond,	1.5
Metropolitan Water District, Spot Pond,	1.6
Metropolitan Water District, tap in Quincy,	1.6
Haverhill, Pentucket Lake,	1.6
Ipswich, Dow's Brook Reservoir,	1.6
Marlborough, Lake Williams,	1.6
Northampton, Mountain Street Reservoir,	1.6
Metropolitan Water District, tap in Revere,	1.7
Hatfield, reservoir,	1.7
Haverhill, Kenoza Lake,	1.7
Haverhill, Millvale Reservoir,	1.7
Lawrence, Merrimack River, filtered,	1.7
Lee, Codding Brook,	1.7
Northampton, West Brook,	1.7
North Adams, Broad Brook,	1.8
Salem, Longham Reservoir,	1.8
Whitman, Hobart's Pond,	1.8
Haverhill, Johnson's Pond,	1.9
Wakefield, Crystal Lake,	1.9
Metropolitan Water District, Lake Cochituate,	2.0
Winchester, North Reservoir,	2.0
Cambridge, Lower Hobbs Brook Reservoir,	2.1
Holyoke, Wright and Ashley Pond,	2.1
Natick, Dug Pond,	2.1
Cambridge, Stony Brook Reservoir,	2.2

TABLE No. 21. — *Hardness of Surface Waters* — Concluded.

[Parts per 100,000.]

Salem, Wenham Lake,	2.2
Pittsfield, Ashley Lake,	2.3
Holyoke, Whiting Street Reservoir,	2.4
Longmeadow, Cooley Brook,	2.4
Adams, Bassett Brook,	2.5
West Springfield, Darby Brook Reservoir,	2.6
Williamstown, Paul Brook,	2.8
Great Barrington, East Mountain Reservoir,	3.0
Cambridge, Fresh Pond,	3.2
Lynn, Saugus River,	3.2
Cheshire, Thunder Brook,	3.3
Greenfield, Glen Brook Reservoir,	3.3
Deerfield, Roaring Brook,	3.5
Williamstown, Flora Glen Reservoir,	3.5
Cheshire, Kitchen Brook,	3.6
Pittsfield, Mill Brook Reservoir,	3.6
Stockbridge, Lake Averic,	3.7
Pittsfield, Ashley Brook,	4.6
Adams, Dry Brook,	4.9
North Adams, Notch Brook Reservoir,	5.0
Pittsfield, Sacket Brook,	5.1
Lenox, reservoir,	5.8
Great Barrington, Green River,	6.4
Pittsfield, Hathaway Brook,	6.7

NITRATES IN SURFACE WATERS.

The determination of nitrates is of much less importance in surface waters than in ground waters. It serves, however, in a general way as an index of pollution, especially in the streams, and to a less extent in the larger ponds and reservoirs, since under the latter conditions they are quickly absorbed by growing organisms. The average quantity found in the various waters is shown by the following table: —

TABLE No. 22. — *Nitrates in Surface Waters.*

[Parts per 100,000.]

Falmouth, Long Pond,	.0006
Great Barrington, East Mountain Reservoir,	.0008
Barre, reservoir,	.0010
Gloucester, Haskell Brook Reservoir,	.0010
New Bedford, Great Quittacas Pond,	.0010
Haverhill, Kenoza Lake,	.0011
Peabody, Spring Pond,	.0012
Brockton, Silver Lake,	.0013
Brockton, Salisbury Brook Reservoir,	.0014
New Bedford, Little Quittacas Pond,	.0014
New Bedford, tap in City Hall,	.0014
Wareham, Jonathan's Pond,	.0015
Danvers, Middleton Pond,	.0016
Fitchburg, Meetinghouse Pond,	.0016
Gloucester, Wallace Reservoir,	.0016
Hingham, Accord Pond,	.0016
Plymouth, Little South Pond,	.0016
Taunton, Assawompsett Pond,	.0016
Taunton, Elder's Pond,	.0017
Concord, Sandy Pond,	.0018
Fall River, North Watuppa Lake,	.0018
Nantucket, Wannacomet Pond,	.0018
Springfield, Chapin Pond,	.0018
Springfield, Five Mile Pond,	.0018
Haverhill, Crystal Lake,	.0019
Haverhill, Pentucket Lake,	.0019
Lynn, Glen Lewis Reservoir,	.0019
Northbridge, Cook Allen Reservoir,	.0019
Abington, Big Sandy Pond,	.0020
Andover, Haggett's Pond,	.0020
North Andover, Great Pond,	.0020
Rutland, Muschopauge Lake,	.0020
Leominster, Haynes Reservoir,	.0021

TABLE NO. 22. — *Nitrates in Surface Waters* — Continued.

[Parts per 100,000.]

Leominster, Fall Brook Reservoir,	.0021
Lynn, Walden Reservoir,	.0021
New Bedford, old storage reservoir,	.0021
Northfield, reservoir,	.0021
Haverhill, Johnson's Pond,	.0022
Holyoke, Whiting Street Reservoir,	.0024
Leominster, Morse Reservoir,	.0024
Worcester, Upper Holden Reservoir,	.0024
Palmer, Lower Reservoir,	.0025
Metropolitan Water District, Ashland Reservoir,	.0026
Fitchburg, Scott Reservoir,	.0026
Metropolitan Water District, Wachusett Reservoir,	.0027
Worcester, Lower Holden Reservoir,	.0027
Lynn, Breed's Reservoir,	.0028
Stockbridge, Lake Averic,	.0028
Winchester, North Reservoir,	.0028
Athol, Buckman Brook Reservoir,	.0029
Haverhill, Millvale Reservoir,	.0029
Holyoke, Manhan River,	.0029
Gloucester, Dike's Brook Reservoir,	.0030
Weymouth, Great Pond,	.0030
Lynn, Hawkes Reservoir,	.0031
Lee, Upper Reservoir on Codding Brook,	.0032
Westfield, Montgomery Reservoir,	.0032
Metropolitan Water District, Spot Pond,	.0033
Chicopee, Cooley Brook,	.0033
Holyoke, Wright and Ashley Pond,	.0033
Northampton, Middle Reservoir,	.0033
Norwood, Buckmaster Pond,	.0033
Peabody, Brown's Pond,	.0033
Southbridge, Hatchet Brook Reservoir,	.0033
Maynard, White Pond,	.0034
North Adams, Notch Brook Reservoir,	.0034
Williamstown, Flora Glen Reservoir,	.0034
Cambridge, Lower Hobbs Brook Reservoir,	.0035
Amherst, Amethyst Brook Reservoir,	.0037
Northampton, West Brook,	.0037
Westfield, Tillotson Brook,	.0037
Winchester, South Reservoir,	.0037
Marlborough, Lake Williams,	.0038
Metropolitan Water District, Hopkinton Reservoir,	.0039
Huntington, Cold Brook,	.0040
Montague, Lake Pleasant,	.0040
Hinsdale, storage reservoir,	.0041
Pittsfield, Ashley Lake,	.0041
Athol, Phillipston Reservoir,	.0042
Randolph, Great Pond,	.0042
Ipswich, Dow's Brook Reservoir,	.0044
Lynn, Birch Reservoir,	.0044
South Hadley, Leaping Well Reservoir,	.0045
Hudson, Gates Pond,	.0046
Easthampton, Bassett Brook,	.0048
Lenox, reservoir,	.0048
Springfield, Ludlow Canal,	.0048
North Brookfield, Doane Pond,	.0049
Winchester, Middle Reservoir,	.0049
Lynn, Saugus River,	.0051
Northampton, Mountain Street Reservoir,	.0051
Northborough, Lower Reservoir,	.0051
Spencer, Shaw Pond,	.0051
Chicopee, Morton Brook,	.0052
Lynn, tap,	.0053
Springfield, Ludlow Reservoir,	.0055
Metropolitan Water District, tap in Revere,	.0057
Lee, Codding Brook,	.0057
West Springfield, Darby Brook Reservoir,	.0057
Metropolitan Water District, Framingham Reservoir No. 2,	.0058
North Brookfield, North Pond,	.0058
Salem, Wenham Lake,	.0062
Wayland, Snake Brook Reservoir,	.0062
Worcester, Leicester Reservoir,	.0064

Table No. 22.— *Nitrates in Surface Waters*— Concluded.

[Parts per 100,000.]

Metropolitan Water District, Nashua River,	.0066
Cheshire, Kitchen Brook,	.0069
Chester, Austin Brook,	.0070
Whitman, Hobart's Pond,	.0070
Worcester, Kent Reservoir,	.0070
Marlborough, Millham Brook Reservoir,	.0071
Pittsfield, Mill Brook,	.0071
Gardner, Crystal Lake,	.0073
Wakefield, Crystal Lake,	.0073
Metropolitan Water District, Lake Cochituate,	.0076
Rockport, Cape Pond,	.0077
Deerfield, Roaring Brook,	.0080
Pittsfield, Ashley Brook,	.0080
Adams, Dry Brook,	.0084
Cheshire, Thunder Brook,	.0085
Metropolitan Water District, Sudbury Reservoir,	.0090
Metropolitan Water District, Chestnut Hill Reservoir,	.0105
Metropolitan Water District, tap in State House,	.0119
Hatfield, reservoir,	.0119
Metropolitan Water District, Framingham Reservoir No. 3,	.0120
Greenfield, Glen Brook Reservoir,	.0121
Natick, Dug Pond,	.0137
Cambridge, Stony Brook Reservoir,	.0138
Pittsfield, Hathaway Brook,	.0140
Pittsfield, Sacket Brook,	.0141
Salem, Longham Reservoir,	.0143
Williamstown, Paul Brook,	.0149
Metropolitan Water District, tap in Quincy,	.0155
Adams, Bassett Brook,	.0159
Dalton, Egypt Brook Reservoir,	.0162
Milford, Charles River, filtered,	.0165
North Adams, Broad Brook,	.0179
Cambridge, Fresh Pond,	.0245
Lawrence, Merrimack River, filtered,	.0255
South Hadley, Buttery Brook Reservoir,	.0262
Longmeadow, Cooley Brook,	.0265
Great Barrington, Green River,	.0270

Residue on Evaporation in Surface Waters.

The amount of dissolved mineral matter found in the waters of the State is, in general, highest in Berkshire, where many of the waters dissolve limestone from the rocks and soil over which they flow, and it is also large in the ponds and reservoirs nearest the sea. Except in these cases a high total residue is usually an indication of sewage pollution.

The highest residue found in any water is in Cape Pond in Rockport, due probably to pollution by wastes from a glue factory. Wannacomet Pond in Nantucket, though having a high total residue, is free from pollution, and the large quantity of mineral matter is doubtless to be explained by the nearness of the pond to the ocean. The high total residue in the water of the Saugus River is due to pollution from the large population on its water-shed. The large quantity of mineral matter found in the waters of Great Barrington, Pittsfield, Lenox, Adams, North Adams and other towns in the western part of the State is due to the contact of the water with limestone.

The residue on evaporation in the various surface-water supplies of the State is shown by the following table: —

TABLE No. 23. — *Residue on Evaporation in Surface Waters.*

[Parts per 100,000.]

Hinsdale, storage reservoir,	2.06
Worcester, Upper Holden Reservoir,	2.16
Leominster, Fall Brook Reservoir,	2.17
Rutland, Muschopauge Lake,	2.17
Leominster, Morse Reservoir,	2.24
Springfield, Chapin Pond,	2.25
Leominster, Haynes Reservoir,	2.26
Worcester, Lower Holden Reservoir,	2.26
Spencer, Shaw Pond,	2.31
Wareham, Jonathan's Pond,	2.33
Fitchburg, Meetinghouse Pond,	2.36
Concord, Sandy Pond,	2.37
Montague, Lake Pleasant,	2.46
Fitchburg, Scott Reservoir,	2.47
Plymouth, Little South Pond,	2.48
Springfield, Five Mile Pond,	2.50
Hudson, Gates Pond,	2.53
South Hadley, Leaping Well Reservoir,	2.59
Dalton, Egypt Brook Reservoir,	2.60
Westfield, Tillotson Brook,	2.61
Westfield, Montgomery Reservoir,	2.65
Maynard, White Pond,	2.67
Taunton, Elder's Pond,	2.75
Lee, Upper Reservoir on Codding Brook,	2.79
Metropolitan Water District, Wachusett Reservoir,	2.86
Springfield, Ludlow Reservoir,	2.88
Falmouth, Long Pond,	2.90
Hingham, Accord Pond,	2.90
Northfield, reservoir,	2.94
Brockton, Silver Lake,	2.95
Chester, Austin Brook,	3.00
Worcester, Leicester Reservoir,	3.01
Haverhill, Crystal Lake,	3.02
Norwood, Buckmaster Pond,	3.04
Lynn, Glen Lewis Reservoir,	3.08
Peabody, Brown's Pond,	3.10
Northbridge, Cook Allen Reservoir,	3.13
Southbridge, Hatchet Brook Reservoir,	3.15
Winchester, South Reservoir,	3.15
Andover, Haggett's Pond,	3.16
Taunton, Assawompsett Pond,	3.16
Huntington, Cold Brook,	3.17
North Brookfield, Doane Pond,	3.21
Abington, Big Sandy Pond,	3.22
Worcester, Kent Reservoir,	3.24
New Bedford, tap in City Hall,	3.32
Athol, Buckman Brook Reservoir,	3.34
New Bedford, Little Quittacas Pond,	3.34
Fall River, North Watuppa Lake,	3.35
North Brookfield, North Pond,	3.35
Amherst, Amethyst Brook Reservoir,	3.36
Palmer, Lower Reservoir,	3.36
North Andover, Great Pond,	3.39
New Bedford, Great Quittacas Pond,	3.42
Winchester, Middle Reservoir,	3.42
Athol, Phillipston Reservoir,	3.43
Chicopee, Morton Brook,	3.46
Springfield, Ludlow Canal,	3.46
Lynn, Walden Reservoir,	3.50
Lynn, Breed's Reservoir,	3.51
Metropolitan Water District, Ashland Reservoir,	3.55
Easthampton, Bassett Brook,	3.55
Lee, Codding Brook,	3.56
Haverhill, Pentucket Lake,	3.61
Metropolitan Water District, Nashua River,	3.63
North Adams, Broad Brook,	3.63
Barre, reservoir,	3.65
Holyoke, Manhan River,	3.67
Northampton, Mountain Street Reservoir,	3.67
Metropolitan Water District, Sudbury Reservoir,	3.68

TABLE NO. 23. — *Residue on Evaporation in Surface Waters* — Concluded.

[Parts per 100,000.]

Metropolitan Water District, Hopkinton Reservoir,	3.70
Brockton, Salisbury Brook Reservoir,	3.70
Haverhill, Kenoza Lake,	3.71
Adams, Bassett Brook,	3.72
Northborough, Lower Reservoir,	3.74
Gardner, Crystal Lake,	3.76
Gloucester, Dike's Brook Reservoir,	3.78
Northampton, West Brook,	3.78
South Hadley, Buttery Brook Reservoir,	3.78
Danvers, Middleton Pond,	3.81
Metropolitan Water District, Framingham Reservoir No. 3,	3.85
Metropolitan Water District, Chestnut Hill Reservoir,	3.87
Hatfield, reservoir,	3.88
Northampton, Middle Reservoir,	3.88
Weymouth, Great Pond,	3.89
Milford, Charles River, filtered,	3.93
Metropolitan Water District, Spot Pond,	3.94
Metropolitan Water District, tap in Revere,	3.95
Marlborough, Millham Brook Reservoir,	3.95
Randolph, Great Pond,	3.96
Lynn, Birch Reservoir,	3.98
Peabody, Spring Pond,	4.00
Metropolitan Water District, tap in State House,	4.01
Haverhill, Johnson's Pond,	4.03
Gloucester, Haskell Brook Reservoir,	4.06
Metropolitan Water District, tap in Quincy,	4.07
Lynn, tap,	4.10
Chicopee, Cooley Brook,	4.12
Marlborough, Lake Williams,	4.12
Williamstown, Paul Brook,	4.15
Gloucester, Wallace Reservoir,	4.17
Metropolitan Water District, Framingham Reservoir No. 2,	4.19
Holyoke, Wright and Ashley Pond,	4.20
Holyoke, Whiting Street Reservoir,	4.24
Lynn, Hawkes Reservoir,	4.37
Cheshire, Thunder Brook,	4.42
Ipswich, Dow's Brook Reservoir,	4.45
Wakefield, Crystal Lake,	4.49
Longmeadow, Cooley Brook,	4.50
Winchester, North Reservoir,	4.51
Wayland, Snake Brook Reservoir,	4.53
Great Barrington, East Mountain Reservoir,	4.56
Lawrence, Merrimack River, filtered,	4.56
Pittsfield, Ashley Lake,	4.57
Haverhill, Millvale Reservoir,	4.77
New Bedford, old storage reservoir,	4.77
Metropolitan Water District, Lake Cochituate,	4.85
Cambridge, Lower Hobbs Brook Reservoir,	4.89
Natick, Dug Pond,	4.95
Cheshire, Kitchen Brook,	5.01
Pittsfield, Mill Brook,	5.03
Greenfield, Glen Brook Reservoir,	5.10
West Springfield, Darby Brook Reservoir,	5.13
Cambridge, Stony Brook Reservoir,	5.42
Williamstown, Flora Glen Reservoir,	5.43
Salem, Wenham Lake,	5.47
Stockbridge, Lake Averic,	5.70
Deerfield, Roaring Brook,	5.82
Pittsfield, Ashley Brook,	6.13
Whitman, Hobart's Pond,	6.22
Salem, Longham Reservoir,	6.26
Pittsfield, Sacket Brook,	6.43
North Adams, Notch Brook Reservoir,	6.75
Nantucket, Wannacomet Pond,	6.78
Cambridge, Fresh Pond,	6.88
Adams, Dry Brook,	7.22
Lynn, Saugus River,	7.49
Lenox, reservoir,	8.05
Pittsfield, Hathaway Brook,	8.28
Great Barrington, Green River,	8.39
Rockport, Cape Pond,	9.12

GROUND-WATER SUPPLIES.

The ground-water supplies in the State are fewer in number than the surface-water sources, and supply in the aggregate a much smaller number of people. Most of the older water works systems which serve the larger communities are supplied from surface sources, while the newer supplies are in most cases obtained from the ground. The most common method of obtaining ground water is by means of tubular wells, ranging in depth from 25 feet to 50 feet or more, and more ground-water supplies are obtained in this way than by any other method. Next in number are the supplies obtained from large circular wells, generally from 20 feet to 40 feet deep; then come the filter-galleries, so called, which are usually elongated wells 10 feet to 20 feet in depth, located along the shore of a pond or near a stream. The filter-galleries are usually rectangular in section, though sometimes of irregular shape, and are in some cases several hundred feet in length. Both the large wells and the filter-galleries are in many cases supplemented by tubular wells sunk in their bottoms or in their immediate neighborhood. A few ground-water supplies are obtained directly from natural springs.

Normal ground waters are colorless, contain very little organic matter, and are ordinarily affected by mineral matter in no greater degree than the surface waters of the same region. On account of their attractive appearance and freedom from color, taste or odor, their low temperature in summer, and the greater safety in their use as compared with surface waters, especially in populous regions, ground waters are much the more desirable sources of water supply if they can be obtained. Most of the larger supplies of ground water, such as those at Lowell, Brookline, Newton, Waltham, Woburn, etc., are obtained from the neighborhood of large streams or ponds, and while the water is derived in part from the rain which falls upon and sinks into the ground in the neighborhood of the collecting works, it is derived largely, and in many cases chiefly, from the water which percolates through the ground from the neighboring pond or stream. The surface waters which percolate from ponds or streams through the ground to the various filter-galleries or wells are in most cases well purified in their passage through the soil, and become ground waters, differing in no important respect from the waters of wells or springs supplied wholly by the rainfall upon porous soil about them; but some of the ground waters derived from such sources deteriorate in quality after a time on account of a gradual reduction in the efficiency of the purification effected in their passage through the soil. This is especially apt to be the case when the distance from the surface source to the well is quite short. The marked characteristics of such deterioration are an increased quantity of iron and ammonia, and the presence of turbidity, sediment and color, and such deterioration has in some cases become so great as to cause the abandonment of the source of supply.

The averages of the analyses of all the ground-water sources made during the past five years have been calculated in the same way as those of the surface-water sources, and the results are presented in the following table, in which the analyses of the various sources are given alphabetically by towns.

The ground-water sources have been examined generally once in two or three months, but in a few cases as often as once a month.

Some of the sources have been in use for a period of less than five years, and these are mentioned in the notes following the table.

TABLE NO. 24. — *Averages of Chemical Analyses from 1900 to 1904 inclusive.*

[Parts per 100,000.]

CITY OR TOWN.	Source.	Color.	Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
Adams, . . .	Tubular wells,*	.00	13.60	.0001	.0005	0.09	.0440	.0000	.01	9.7	.0035
Amesbury, . .	Main Street wells, . .	.09	10.33	.0018	.0015	0.78	.0816	.0002	.03	4.4	.0570
	Market Street wells, . .	.01	25.09	.0036	.0028	1.31	.0047	.0002	.04	11.7	.0094
Attleborough, .	Well, ...	.01	4.02	.0006	.0031	0.34	.0092	.0000	.05	1.8	.0070
Avon, . . .	Well, ...	.00	3.70	.0005	.0011	0.35	.0419	.0000	.01	1.1	.0045
Ayer, . . .	Well, ...	.00	5.51	.0005	.0018	0.44	.0384	.0000	.02	2.2	.0088
Billerica, . .	Tubular wells, . . .	.06	6.50	.0009	.0026	0.27	.0080	.0000	.08	2.3	.0327
Braintree, . .	Filter-gallery, . . .	.06	5.09	.0017	.0078	0.81	.0406	.0000	.17	1.7	.0083
Bridgewater, .	Wells, ...	.13	6.91	.0007	.0031	0.45	.0163	.0000	.06	2.3	.0849
Brookline, . .	Tubular wells and filter-gallery.	.04	9.02	.0036	.0041	0.58	.0362	.0002	.10	4.6	.0123
Canton, . . .	Springdale well, . . .	.00	3.61	.0002	.0010	0.32	.0042	.0000	.02	1.0	.0079
	Well near Henry's Spring,	.04	3.94	.0002	.0023	0.37	.0190	.0000	.08	1.2	.0063
Cohasset, . .	Tubular wells No. 1, . .	.04	13.24	.0006	.0020	1.66	.0344	.0000	.03	6.0	.0215
	Tubular wells No. 2, . .	.01	13.54	.0003	.0017	1.44	.0807	.0000	.02	5.6	.0079
	Filter-gallery,* . . .	.11	11.14	.0591	.0093	1.13	.0041	.0001	.28	5.1	.0134
Cottage City, .	Springs, ...	.02	3.89	.0003	.0013	0.95	.0102	.0000	.02	0.6	.0133
Dedham, . .	Large well, ...	.00	8.97	.0010	.0038	0.76	.1619	.0000	.04	3.8	.0060
	Tubular wells, ...	.00	13.97	.0012	.0016	1.30	.4011	.0002	.02	5.4	.0102
Dracut, . . .	Tubular wells, ...	.00	4.60	.0005	.0015	0.22	.0224	.0000	.02	1.7	.0061
Easton, . . .	Well, ...	.00	4.43	.0003	.0015	0.49	.0524	.0000	.01	1.5	.0052
Fairhaven, . .	Tubular wells, ...	.36	6.36	.0008	.0095	0.91	.0299	.0001	.50	1.9	.0356
Foxborough, .	Tubular wells, ...	.00	3.58	.0002	.0006	0.34	.0419	.0000	.01	0.7	.0072
Framingham, .	Filter-gallery, . . .	.02	8.17	.0033	.0050	0.85	.0337	.0003	.06	3.8	.0133
Franklin, . .	Wells,*	.38	6.43	.0031	.0156	0.63	.1027	.0002	.48	2.1	.0169

* See notes.

TABLE NO. 24. — *Averages of Chemical Analyses from 1900 to 1904 inclusive* — Continued.

[Parts per 100,000.]

City or Town.	Source.	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
Grafton, . .	Filter-gallery, . . .	.04	10.27	.0003	.0029	1.24	.2273	.0000	.06	3.7	.0068
Groton, . . .	Well, ...	.00	4.31	.0003	.0009	0.16	.0079	.0000	.01	1.9	.0059
Hingham, . .	Wells,*	.02	5.27	.0009	.0023	0.71	.0115	.0000	.04	2.0	.0170
Holliston, . .	Well,*	.27	3.80	.0008	.0111	0.28	.0044	.0000	.32	1.2	.0266
Hopkinton, . .	Tubular wells, . . .	.00	11.52	.0003	.0019	1.09	.3805	.0000	.02	4.6	.0094
Hyde Park, . .	Tubular wells near the Neponset River.	.05	10.37	.0107	.0042	1.23	.1011	.0002	.09	4.4	.0341
	Tubular wells near Mother Brook.	.05	8.18	.0007	.0049	0.90	.1928	.0000	.12	3.1	.0069
Kingston, . .	Tubular wells, . . .	.00	4.60	.0005	.0015	0.77	.0217	.0000	.01	0.9	.0074
Leicester, . .	Wells, ...	.09	6.11	.0028	.0050	0.21	.0797	.0000	.15	2.4	.0164
Lowell, . . .	Cook wells (tubular),* .	.06	8.86	.0032	.0048	0.50	.0413	.0000	.10	3.6	.0297
	Boulevard wells (tubular),	.05	4.16	.0049	.0034	0.24	.0163	.0001	.08	1.6	.0360
Manchester, . .	Large well, ...	.00	11.15	.0002	.0007	1.83	.1447	.0000	.01	3.7	.0073
	Tubular wells, . . .	.00	9.73	.0008	.0015	1.27	.1900	.0000	.02	2.5	.0045
Mansfield, . .	Well, ...	.00	2.72	.0002	.0005	0.25	.0021	.0000	.01	0.5	.0039
Marblehead, . .	Well No. 1, ...	.08	16.99	.0140	.0026	2.27	.0213	.0002	.06	7.0	.1895
	Well No. 2, ...	.10	17.26	.0260	.0034	1.66	.0051	.0001	.09	6.8	.3868
Marshfield, . .	Well, ...	.00	11.88	.0004	.0010	3.44	.0748	.0000	.03	2.3	.0078
Medfield, . .	Spring, ...	.00	3.85	.0006	.0034	0.23	.0019	.0000	.07	1.0	.0046
Methuen, . .	Tubular wells, . . .	.09	7.63	.0005	.0049	0.33	.0187	.0000	.10	3.4	.0210
Middleborough, .	Well, ...	.18	6.17	.0022	.0047	0.65	.0565	.0000	.13	2.3	.0822
Millbury, . .	Well, ...	.01	6.05	.0003	.0019	0.24	.0229	.0000	.03	2.7	.0052
Millis, . . .	Spring, ...	.00	7.22	.0003	.0023	0.59	.1774	.0000	.02	2.8	.0055
Monson, . .	Well, ...	.00	3.23	.0003	.0008	0.12	.0099	.0000	.01	1.0	.0058
Nantucket, . .	Wells, ...	.04	7.00	.0058	.0062	2.12	.0128	.0000	.07	1.6	.0235
Natick, . . .	Well,*	.00	8.05	.0004	.0013	0.49	.0297	.0000	.02	4.3	.0051
Needham, . .	Well No. 1, ...	.00	5.62	.0003	.0014	0.60	.1466	.0000	.01	2.0	.0041
	Well No. 2, ...	.00	6.24	.0004	.0017	0.62	.1601	.0000	.01	2.3	.0047
	Hicks Spring,* . . .	.00	4.63	.0003	.0011	0.48	.0857	.0000	.00	1.5	.0058
Newburyport, .	Wells, ...	.08	6.06	.0004	.0036	0.47	.0231	.0000	.07	2.4	.0367
Newton, . .	Tubular wells and filter-gallery.	.03	6.02	.0006	.0034	0.45	.0378	.0000	.08	2.6	.0067
No. Attleborough,	Well, ...	.00	6.36	.0003	.0016	0.63	.0512	.0000	.03	2.9	.0089
Provincetown, .	Well, ...	.91	10.78	.0148	.0181	2.55	.0051	.0001	.78	2.8	.4647
Reading, . .	Filter-gallery,* . . .	.63	8.33	.0101	.0111	0.46	.0043	.0000	.53	2.9	.1972

* See notes.

TABLE No. 24. — *Averages of Chemical Analyses from 1900 to 1904 inclusive* — Concluded.

[Parts per 100,000.]

CITY OR TOWN.	Source.	Color.	Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
Reading,	Filtered water,	.20	15.26	.0066	.0081	0.47	.0042	.0009	.32	8.8	.0121
Scituate,	Wells,	.01	15.45	.0005	.0010	3.60	.1728	.0000	.02	4.5	.0088
Sharon,	Well,	.00	9.26	.0002	.0010	1.14	.2576	.0000	.01	3.5	.0057
Sheffield,	Spring,	.00	3.46	.0004	.0012	0.07	.0064	.0000	.01	1.9	.0076
Shirley,	Well,*	.01	2.45	.0002	.0008	0.14	.0022	.0000	.01	0.7	.0108
Tisbury,	Spring,	.00	4.25	.0002	.0009	1.02	.0053	.0000	.02	0.5	.0111
Uxbridge,	Spring,*	.00	2.44	.0002	.0022	0.15	.0055	.0000	.04	0.4	–
Walpole,	Tubular wells,	.00	3.92	.0001	.0006	0.33	.0160	.0000	.01	1.1	.0077
Waltham,	Well,	.06	7.14	.0031	.0041	0.58	.0269	.0000	.09	3.4	.0236
Ware,	Well,	.00	8.19	.0001	.0009	0.66	.3015	.0000	.01	2.9	.0047
Webster,	Well,	.00	3.75	.0004	.0011	0.24	.0224	.0000	.02	1.4	.0079
Wellesley,	Tubular wells,	.01	7.63	.0019	.0012	0.64	.1433	.0016	.02	3.3	.0079
	Well at Williams Spring,	.00	9.67	.0007	.0024	0.83	.3587	.0004	.04	3.5	.0059
	Filter-gallery,	.00	7.00	.0006	.0023	0.48	.0952	.0001	.04	2.8	.0038
Westborough,	Filter basin,*	.02	2.82	.0007	.0088	0.20	.0018	.0000	.13	1.1	–
Weston,	Well,	.09	6.83	.0004	.0053	0.45	.0452	.0000	.15	3.0	.0076
West Springfield,	Well,	.00	7.12	.0003	.0014	0.49	.2232	.0000	.01	2.5	.0064
Williamstown,	Cold Spring,	.01	13.12	.0004	.0017	0.06	.0374	.0000	.07	10.7	.0073
	Sherman Spring,	.02	9.52	.0003	.0045	0.06	.0143	.0000	.03	6.4	.0070
Winchendon,	Well,	.02	3.05	.0015	.0017	0.11	.0045	.0000	.03	0.9	.0178
Woburn,	Filter-gallery,	.00	9.68	.0062	.0031	1.17	.0192	.0000	.06	4.8	.0046

* See notes.

NOTES.

Adams, Tubular wells. — Completed in 1902. The water is used only in the drier portions of the year, and is pumped into Bassett Brook and thence supplied to the town.

Cohasset, Filter-gallery. — Situated on the shore of Lily Pond. It is used as an auxiliary source of supply in the drier portions of the year.

Franklin. — Water from Beaver Pond is mingled with the well water before it is supplied to the town.

Hingham, Wells. — Completed in the latter part of the year 1903.

Holliston, Well. — Probably receives water directly from the adjacent pond.

Lowell, Cook wells. — These wells are not used, the water containing an excessive quantity of carbonic acid which causes it to take up lead in large quantities from the lead service pipes through which water is supplied.

Natick, Well. — Was completed and has been used for the supply of the town since 1903.

Needham, Hicks Spring. — Works for taking water from this source were built in 1904.

Reading, Filter-gallery. — The water from the filter-gallery contains an excessive quantity of iron and is treated with lime and alum and subsequently filtered through a mechanical filter. The filtered water represents the water after treatment and filtration.

Shirley, Well. — Water from this source was first used in 1903.

Uxbridge, Spring. — The analyses cover a period of one year.

Westborough, Filter basin. — The water supply of Westborough is taken from a large open basin fed by water which filters through the ground from Sandra Pond and by ground water from adjacent territory.

The most important consideration in comparing the quality of various ground waters is their relative freedom from sewage pollution. In the case of surface waters it is usually a simple matter to determine with reasonable accuracy the population within the water-shed of a source of supply which may affect the quality of its water, but in the case of a ground-water supply the area from which water percolates to the source is often indefinite and rarely determinable with accuracy, and some further means of determining the degree to which it is affected by population in the region about it is usually necessary.

Ground waters drawn from populous regions show very clearly upon chemical analysis the effect of the pollution of the water by sewage or other wastes of human life. Chlorine, though a normal constituent of the waters of all parts of the State, is a characteristic ingredient of sewage, and the normal quantity having been determined, the excess due to sewage or the wastes of human life and industry can be ascertained. The normal chlorine of the waters of the State is greatest near the sea, and decreases as the distance from the sea increases. It changes very rapidly within short distances near the seashore, and in consequence of a lack of sufficient information in some cases the normal at such places is still uncertain, but very few of the ground waters of the State are affected by this uncertainty.

The ground waters have been classified in accordance with the determination of the excess of chlorine above the normal on the same basis as that used for the examination of spring waters in 1900, and the results are presented in the tables which follow.

The first group includes normal waters and those in which the excess of chlorine above the normal is not more than .10 of a part per 100,000. The second group includes those waters in which the excess of chlorine above the normal is between .11 and .30 of a part per 100,000. The third group includes those waters in which the excess of chlorine above the normal is more than .30 of a part per 100,000.

TABLE NO. 25. — *Ground-water Sources arranged in Groups according to the Excess of Chlorine above the Normal.*

GROUP I. — *Normal Ground Waters and Those in which the Excess of Chlorine is Less than .10 of a Part per 100,000.*

City or Town.	Source.	City or Town.	Source.
Adams, . . .	Tubular wells.	Canton, . . .	Well near Henry's Spring.
Attleborough, . .	Well.	Cohasset, . . .	Filter-gallery.
Avon, ...	Well.	Cottage City, . .	Springs.
Billerica, . . .	Tubular wells.	Dracut, . . .	Tubular wells.
Bridgewater, . .	Wells.	Foxborough, . .	Tubular wells.
Canton, . . .	Springdale well.	Groton, . . .	Well.

TABLE No 25.—*Ground-water Sources arranged in Groups, etc.*—Continued.

GROUP I.—*Normal Ground Waters and Those in which the Excess of Chlorine is not More than .10 of a Part per 100,000*—Concluded.

[Parts per 100,000.]

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
Hingham,	Wells.	Nantucket,	Wells.
Holliston,	Well.	Newburyport,	Wells.
Kingston,	Tubular wells.	Provincetown,	Well.
Leicester,	Wells.	Sheffield,	Spring.
Lowell,	Boulevard wells (tubular).	Shirley,	Well.
Mansfield,	Well.	Tisbury,	Spring.
Marblehead,	Well No. 1.	Uxbridge,	Spring.
Marblehead,	Well No. 2.	Walpole,	Tubular wells.
Marshfield,	Well.	Webster,	Well.
Medfield,	Spring.	Westborough,	Filter basin.
Methuen,	Tubular wells.	Williamstown,	Cold Spring.
Millbury,	Well.	Williamstown,	Sherman Spring.
Monson,	Well.	Winchendon,	Well.

GROUP II.—*Ground Waters in which the Excess of Chlorine is between .11 and .30 of a Part per 100,000.*

Ayer,	Well.	Needham,	Hicks Spring.
Brookline,	Tubular wells and filter-gallery.	Newton,	Tubular wells and filter-gallery.
Easton,	Well.	Reading,	Filter-gallery.
Fairhaven,	Tubular wells.	Reading,	Filtered water.
Lowell,	Cook wells (tubular).	Wellesley,	Filter-gallery.
Middleborough,	Well.	Weston,	Well.
Natick,	Well.		

GROUP III.—*Ground Waters in which the Excess of Chlorine is More than .30 of a Part per 100,000.*

Amesbury,	Main Street wells.	Grafton,	Filter-gallery.
Amesbury,	Market Street wells.	Hopkinton,	Tubular wells.
Braintree,	Filter-gallery.	Hyde Park,	Tubular wells near Mother Brook.
Cohasset,	Tubular wells No. 1.	Hyde Park,	Tubular wells near the Neponset River.
Cohasset,	Tubular wells No. 2.	Manchester,	Large well.
Dedham,	Large well.	Manchester,	Tubular wells.
Dedham,	Tubular wells.	Millis,	Spring.
Framingham,	Filter-gallery.	Needham,	Well No. 1.
Franklin,	Wells.	Needham,	Well No. 2.

TABLE No. 25.— *Ground-water Sources arranged in Groups, etc.*— Concluded.

GROUP III.— *Ground Waters in which the Excess of Chlorine is More than .30 of a Part per 100,000*— Concluded.

CITY OR TOWN.	Source.	CITY OR TOWN.	Source.
North Attleborough, .	Well.	Wellesley, . . .	Tubular wells.
Scituate, . . .	Wells.	Wellesley, . . .	Well at Williams Spring.
Sharon, . . .	Well.	West Springfield, .	Well.
Waltham, . . .	Well.	Woburn, . . .	Filter-gallery.
Ware, ...	Well.		

NITRATES IN GROUND WATERS.

The presence of nitrates in ground waters is a measure, though a somewhat less definite and reliable one in Massachusetts than the excess of chlorine, of the extent to which these waters have been exposed to pollution by sewage before entering the wells from which the water is drawn.

Ground waters from an uninhabited water-shed in which the land has not been cultivated or polluted in any way by animal matter are practically free from nitrates. The use of lands for pasturage tends to increase slightly the quantity of nitrates present in the ground water of the region so used. Ground waters from lands under cultivation, even though free from human habitation, contain a noticeably larger quantity of nitrates than in the cases where the land has been unused or used only for pasturage. In thickly settled regions, where the ground is polluted by house drainage and other animal matter, the nitrates are nearly always very high. Hence this determination is of great value as an indication of previous pollution in ground waters, and, taken in connection with the excess of chlorine, is a very important index of the amount of previous pollution these waters have received. When ground waters are exposed to light, as in an open spring or well, or especially in an open distributing reservoir, the nitrates are absorbed rapidly by organic growths ; and though the quantity may be large in the water as it enters the spring or reservoir, it may be nearly all taken up by the growths therein. While in a general way the quantity of nitrates corresponds directly with the excess of chlorine, there are some cases in which there is considerable disagreement, the reasons for which have not been made clear by the investigations thus far made. In the case of the ground waters taken from near the sea, however, the determination of the normal chlorine is in some cases doubtful, and a considerable disagreement is unavoidable.

The quantity of nitrates present in the various ground waters is given in the following table : —

TABLE NO. 26. — *Nitrates in Ground Waters.*

[Parts per 100,000.]

Westborough, filter basin,	.0018
Medfield, spring,	.0019
Mansfield, well,	.0021
Shirley, well,	.0022
Cohasset, filter-gallery,	.0041
Canton, Springdale well,	.0042
Reading, filtered water,	.0042
Reading, filter-gallery,	.0043
Holliston, well,	.0044
Winchendon, well,	.0045
Amesbury, Market Street wells,	.0047
Marblehead, Well No. 2,	.0051
Provincetown, well,	.0051
Tisbury, spring,	.0053
Uxbridge, spring,	.0055
Sheffield, spring,	.0064
Groton, well,	.0079
Billerica, tubular wells,	.0080
Attleborough, well,	.0092
Monson, well,	.0099
Cottage City, springs,	.0102
Hingham, wells,	.0115
Nantucket, wells,	.0128
Williamstown, Sherman Spring,	.0143
Walpole, tubular wells,	.0160
Bridgewater, wells,	.0163
Lowell, Boulevard wells (tubular),	.0163
Methuen, tubular wells,	.0187
Canton, well near Henry's Spring,	.0190
Woburn, filter-gallery,	.0192
Marblehead, Well No. 1,	.0213
Kingston, tubular wells,	.0217
Dracut, tubular wells,	.0224
Webster, well,	.0224
Millbury, well,	.0229
Newburyport, wells,	.0231
Waltham, well,	.0269
Natick, well,	.0297
Fairhaven, tubular wells,	.0299
Framingham, filter-gallery,	.0337
Cohasset, tubular wells No. 1,	.0344
Brookline, tubular wells and filter-gallery,	.0362
Williamstown, Cold Spring,	.0374
Newton, tubular wells and filter-gallery,	.0378
Ayer, well,	.0384
Braintree, filter-gallery,	.0406
Lowell, Cook wells (tubular),	.0413
Avon, well,	.0419
Foxborough, tubular wells,	.0419
Adams, tubular wells,	.0440
Weston, well,	.0452
North Attleborough, well,	.0512
Easton, well,	.0524
Middleborough, well,	.0565
Marshfield, well,	.0748
Leicester, wells,	.0797
Cohasset, tubular wells No. 2,	.0807
Amesbury, Main Street wells,	.0816
Needham, Hicks Spring,	.0857
Wellesley, filter-gallery,	.0952
Hyde Park, tubular wells near the Neponset River,	.1011
Franklin, wells,	.1027
Wellesley, tubular wells,	.1433
Manchester, large well,	.1447
Needham, Well No. 1,	.1466
Needham, Well No. 2,	.1601
Dedham, large well,	.1619
Scituate, wells,	.1728
Millis, spring,	.1774
Manchester, tubular wells,	.1900
Hyde Park, tubular wells near Mother Brook,	.1928
West Springfield, well,	.2232
Grafton, filter-gallery,	.2273
Sharon, well,	.2576
Ware, well,	.3015
Wellesley, well at Williams Spring,	.3587
Hopkinton, tubular wells,	.3805
Dedham, tubular wells,	.4011

Ammonia in Ground Waters.

Nearly all ground waters, even those of the best springs and wells in unpopulated regions, contain very small quantities of free and albuminoid ammonia, though at times these substances are wholly absent. The determinations of chlorine and nitrates already given are the important means of showing by chemical analysis the comparative degree to which ground waters are affected by pollution; the determinations of the free and albuminoid ammonias in ground waters are indices of the extent to which a polluted water has been purified and freed from organic matter in its passage through the ground. Imperfectly purified waters, or waters which enter wells or springs while still undergoing the process of purification, usually contain considerable quantities of ammonia both free and albuminoid, and the quantity of free ammonia especially is sometimes very large. The ammonia in a ground water may be derived from sewage or from decaying vegetable or organic matter unaffected by sewage. The ammonias present in sewage are very high, but in a thoroughly purified sewage effluent they may be no greater than in a good spring or well water.

The water of an unpolluted pond or reservoir containing a large quantity of ammonia, on account of the presence of organic matter of a vegetable origin, may, after passing through the ground to a filter-gallery or well, become nearly or quite as free from ammonia as the natural ground water of the region.

Some of the filter-galleries and wells located near streams and ponds have now been in use as public water supplies for many years. In some cases the quality of the water shows no material change from the time the first examination was made, but in other cases the quantity of free and albuminoid ammonia has increased, indicating that a part at least of the water entering these sources is imperfectly purified. In imperfectly purified waters the increase in ammonias is usually accompanied by an increase in iron and in nitrites, and later by the presence of turbidity, sediment and color.

Some ground waters are affected by the presence of organic matter in the ground from which they are drawn. A notable instance of this is the source of supply of the town of Provincetown, where the water drawn from the wells contains very large quantities of ammonia and iron, evidently derived from organic matter deeply buried in the ground in which the wells are located. Ground waters from beneath swamps or deep layers of peaty soil usually show similar characteristics. The quantity of albuminoid ammonia and free ammonia found in the various ground-water supplies of the State are given in the following tables, Nos. 27 and 28: —

TABLE No. 27. — *Albuminoid Ammonia in Ground Waters.*

[Parts per 100,000.]

Adams, tubular wells,	.0005
Mansfield, well,	.0005
Foxborough, tubular wells,	.0006
Walpole, tubular wells,	.0006
Manchester, large well,	.0007
Monson, well,	.0008
Shirley, well,	.0008
Groton, well,	.0009
Tisbury, spring,	.0009
Ware, well,	.0009
Canton, Springdale well,	.0010
Marshfield, well,	.0010
Scituate, wells,	.0010
Sharon, well,	.0010
Avon, well,	.0011
Needham, Hicks Spring,	.0011
Webster, well,	.0011
Sheffield, spring,	.0012
Wellesley, tubular wells,	.0012
Cottage City, springs,	.0013
Natick, well,	.0013
Needham, Well No. 1,	.0014
West Springfield, well,	.0014
Amesbury, Main Street wells,	.0015
Dracut, tubular wells,	.0015
Easton, well,	.0015
Kingston, tubular wells,	.0015
Manchester, tubular wells,	.0015
Dedham, tubular wells,	.0016
North Attleborough, well,	.0016
Cohasset, tubular wells No. 2,	.0017
Needham, Well No. 2,	.0017
Williamstown, Cold Spring,	.0017
Winchendon, well,	.0017
Ayer, well,	.0018
Hopkinton, tubular wells,	.0019
Millbury, well,	.0019
Cohasset, tubular wells No. 1,	.0020
Uxbridge, spring,	.0022
Canton, well near Henry's Spring,	.0023
Hingham, wells,	.0023
Millis, spring,	.0023
Wellesley, filter-gallery,	.0023
Wellesley, well at Williams Spring,	.0024
Billerica, tubular wells,	.0026
Marblehead, Well No. 1,	.0026
Amesbury, Market Street wells,	.0028
Grafton, filter-gallery,	.0029
Attleborough, well,	.0031
Bridgewater, wells,	.0031
Woburn, filter-gallery,	.0031
Lowell, Boulevard wells (tubular),	.0034
Marblehead, Well No. 2,	.0034
Medfield, spring,	.0034
Newton, tubular wells and filter-gallery,	.0034
Newburyport, wells,	.0036
Dedham, large well,	.0038
Brookline, tubular wells and filter-gallery,	.0041
Waltham, well,	.0041
Hyde Park, tubular wells near the Neponset River,	.0042
Williamstown, Sherman Spring,	.0045
Middleborough, well,	.0047
Lowell, Cook wells (tubular),	.0048
Hyde Park, tubular wells near Mother Brook,	.0049
Methuen, tubular wells,	.0049
Framingham, filter-gallery,	.0050
Leicester, wells,	.0050
Weston, well,	.0053
Nantucket, wells,	.0062
Braintree, filter-gallery,	.0078
Reading, filtered water,	.0081
Westborough, filter basin,	.0088
Cohasset, filter-gallery,	.0093
Fairhaven, tubular wells,	.0095
Holliston, well,	.0111
Reading, filter-gallery,	.0111
Franklin, wells,	.0156
Provincetown, well,	.0181

TABLE NO. 28. — *Free Ammonia in Ground Waters.*

[Parts per 100,000.]

Adams, tubular wells,	.0001
Walpole, tubular wells,	.0001
Ware, well,	.0001
Canton, Springdale well,	.0002
Canton, well near Henry's Spring,	.0002
Foxborough, tubular wells,	.0002
Manchester, large well,	.0002
Mansfield, well,	.0002
Sharon, well,	.0002
Shirley, well,	.0002
Tisbury, spring,	.0002
Uxbridge, spring,	.0002
Cohasset, tubular wells No. 2,	.0003
Cottage City, springs,	.0003
Easton, well,	.0003
Grafton, filter-gallery,	.0003
Groton, well,	.0003
Hopkinton, tubular wells,	.0003
Millbury, well,	.0003
Millis, spring,	.0003
Monson, well,	.0003
Needham, Well No. 1,	.0003
Needham, Hicks Spring,	.0003
North Attleborough, well,	.0003
West Springfield, well,	.0003
Williamstown, Sherman Spring,	.0003
Marshfield, well,	.0004
Natick, well,	.0004
Needham, Well No. 2,	.0004
Newburyport, wells,	.0004
Sheffield, spring,	.0004
Webster, well,	.0004
Weston, well,	.0004
Williamstown, Cold Spring,	.0004
Avon, well,	.0005
Ayer, well,	.0005
Dracut, tubular wells,	.0005
Kingston, tubular wells,	.0005
Methuen, tubular wells,	.0005
Scituate, wells,	.0005
Attleborough, well,	.0006
Cohasset, tubular wells No. 1,	.0006
Medfield, spring,	.0006
Newton, tubular wells and filter-gallery,	.0006
Wellesley, filter-gallery,	.0006
Bridgewater, wells,	.0007
Hyde Park, tubular wells near Mother Brook,	.0007
Wellesley, well at Williams Spring,	.0007
Westborough, filter basin,	.0007
Fairhaven, tubular wells,	.0008
Holliston, well,	.0008
Manchester, tubular wells,	.0008
Billerica, tubular wells,	.0009
Hingham, wells,	.0009
Dedham, large well,	.0010
Dedham, tubular wells,	.0012
Winchendon, well,	.0015
Braintree, filter-gallery,	.0017
Amesbury, Main Street wells,	.0018
Wellesley, tubular wells,	.0019
Middleborough, well,	.0022
Leicester, wells,	.0028
Franklin, wells,	.0031
Waltham, well,	.0031
Lowell, Cook wells (tubular),	.0032
Framingham, filter-gallery,	.0033
Amesbury, Market Street wells,	.0036
Brookline, tubular wells and filter-gallery,	.0036
Lowell, Boulevard wells (tubular),	.0049
Nantucket, wells,	.0058
Woburn, filter-gallery,	.0062
Reading, filtered water,	.0066
Reading, filter-gallery,	.0101
Hyde Park, tubular wells near the Neponset River,	.0107
Marblehead, Well No. 1,	.0140
Provincetown, well,	.0148
Marblehead, Well No. 2,	.0260
Cohasset, filter-gallery,	.0591

IRON IN GROUND WATERS.

Many ground waters contain iron in sufficient quantity to produce a rusty precipitate when the water is exposed to air, and the iron becomes oxidized. When iron is present to an amount equal to about .05 of a part per 100,000 it will usually precipitate, giving the water first a milky turbidity and subsequently a rusty sediment. In some ground waters this precipitation takes place rapidly, and the water subsequently becomes again clear and colorless, while in other cases the iron precipitates very slowly and can only be removed from the water within a reasonable time by some less simple method. The quantity of iron varies greatly at different seasons of the year in most of those waters in which it is present in considerable quantity, being insignificant in some seasons, while in others it is present in sufficient quantity to cause serious trouble. The quantity of iron present in the various waters is shown in the following table: —

TABLE NO. 29. — *Iron in Ground Waters.*

[Parts per 100,000.]

Adams, tubular wells,	.0035
Wellesley, filter-gallery,	.0038
Mansfield, well,	.0039
Needham, Well No. 1,	.0041
Avon, well,	.0045
Manchester, tubular wells,	.0045
Medfield, spring,	.0046
Woburn, filter-gallery,	.0046
Needham, Well No. 2,	.0047
Ware, well,	.0047
Natick, well,	.0051
Easton, well,	.0052
Millbury, well,	.0052
Millis, spring,	.0055
Sharon, well,	.0057
Monson, well,	.0058
Needham, Hicks Spring,	.0058
Groton, well,	.0059
Wellesley, well at Williams Spring,	.0059
Dedham, large well,	.0060
Dracut, tubular wells,	.0061
Canton, well near Henry's Spring,	.0063
West Springfield, well,	.0064
Newton, tubular wells and filter-gallery,	.0067
Grafton, filter-gallery,	.0068
Hyde Park, tubular wells near Mother Brook,	.0069
Attleborough, well,	.0070
Williamstown, Sherman Spring,	.0070
Foxborough, tubular wells,	.0072
Manchester, large well,	.0073
Williamstown, Cold Spring,	.0073
Kingston, tubular wells,	.0074
Sheffield, spring,	.0076
Weston, well,	.0076
Walpole, tubular wells,	.0077
Marshfield, well,	.0078
Canton, Springdale well,	.0079
Cohasset, tubular wells No. 2,	.0079
Webster, well,	.0079
Wellesley, tubular wells,	.0079
Braintree, filter-gallery,	.0083
Ayer, well,	.0088
Scituate, wells,	.0088
North Attleborough, well,	.0089
Amesbury, Market Street wells,	.0094
Hopkinton, tubular wells,	.0094
Dedham, tubular wells,	.0102
Shirley, well,	.0108
Tisbury, spring,	.0111

TABLE NO. 29.—*Iron in Ground Waters*—Concluded.

[Parts per 100,000.]

Reading, filtered water,	.0121
Brookline, tubular wells and filter-gallery,	.0123
Cottage City, springs,	.0133
Framingham, filter-gallery,	.0133
Cohasset, filter-gallery,	.0134
Leicester, wells,	.0164
Franklin, wells,	.0169
Hingham, wells,	.0170
Winchendon, well,	.0178
Methuen, tubular wells,	.0210
Cohasset, tubular wells No. 1,	.0215
Nantucket, wells,	.0235
Waltham, well,	.0236
Holliston, well,	.0266
Lowell, Cook wells (tubular),	.0297
Billerica, tubular wells,	.0327
Hyde Park, tubular wells near the Neponset River,	.0341
Fairhaven, tubular wells,	.0356
Lowell, Boulevard wells (tubular),	.0360
Newburyport, wells,	.0367
Amesbury, Main Street wells,	.0570
Middleborough, well,	.0822
Bridgewater, wells,	.0849
Marblehead, Well No. 1,	.1895
Reading, filter-gallery,	.1972
Marblehead, Well No. 2,	.3868
Provincetown, well,	.4647

HARDNESS OF GROUND WATERS.

The remarks concerning the hardness of surface waters apply also to ground waters. Unpolluted ground waters in most parts of the State are soft, but they are apparently somewhat harder than unpolluted surface waters of the same region. The harder waters are found in the limestone regions located chiefly in the western part of the State and in thickly populated localities where the ground water is affected by sewage and other wastes. Half the ground waters of the State have a hardness of less than 2.5 parts per 100,000, and only 11 have a hardness of more than 5 parts per 100,000. The hardness of the filtered water supplied to the town of Reading is greatly increased by the lime and alum used in the process of purifying this water, which contains an excessive quantity of iron.

TABLE NO. 30.—*Hardness of Ground Waters.*

[Parts per 100,000.]

Uxbridge, spring,	0.4
Mansfield, well,	0.5
Tisbury, spring,	0.5
Cottage City, springs,	0.6
Foxborough, tubular wells,	0.7
Shirley, well,	0.7
Kingston, tubular wells,	0.9
Winchendon, well,	0.9
Canton, Springdale well,	1.0
Medfield, spring,	1.0
Monson, well,	1.0
Avon, well,	1.1
Walpole, tubular wells,	1.1
Westborough, filter basin,	1.1
Canton, well near Henry's Spring,	1.2
Holliston, well,	1.2
Webster, well,	1.4
Easton, well,	1.5
Needham, Hicks Spring,	1.5
Lowell, Boulevard wells (tubular),	1.6
Nantucket, wells,	1.6
Braintree, filter-gallery,	1.7

TABLE NO. 30. — *Hardness of Ground Waters* — Concluded.

[Parts per 100,000.]

Dracut, tubular wells,	1.7
Attleborough, well,	1.8
Fairhaven, tubular wells,	1.9
Groton, well,	1.9
Sheffield, spring,	1.9
Hingham, wells,	2.0
Needham, Well No. 1,	2.0
Franklin, wells,	2.1
Ayer, well,	2.2
Billerica, tubular wells,	2.3
Bridgewater, wells,	2.3
Marshfield, well,	2.3
Middleborough, well,	2.3
Needham, Well No. 2,	2.3
Leicester, wells,	2.4
Newburyport, wells,	2.4
Manchester, tubular wells,	2.5
West Springfield, well,	2.5
Newton, tubular wells and filter-gallery,	2.6
Millbury, well,	2.7
Millis, spring,	2.8
Provincetown, well,	2.8
Wellesley, filter-gallery,	2.8
North Attleborough, well,	2.9
Reading, filter-gallery,	2.9
Ware, well,	2.9
Weston, well,	3.0
Hyde Park, tubular wells near Mother Brook,	3.1
Wellesley, tubular wells,	3.3
Methuen, tubular wells,	3.4
Waltham, well,	3.4
Sharon, well,	3.5
Wellesley, well at Williams Spring,	3.5
Lowell, Cook wells (tubular),	3.6
Grafton, filter-gallery,	3.7
Manchester, large well,	3.7
Dedham, large well,	3.8
Framingham, filter-gallery,	3.8
Natick, well,	4.3
Amesbury, Main Street wells,	4.4
Hyde Park, tubular wells near the Neponset River,	4.4
Scituate, wells,	4.5
Brookline, tubular wells and filter-gallery,	4.6
Hopkinton, tubular wells,	4.6
Woburn, filter-gallery,	4.8
Cohasset, filter-gallery,	5.1
Dedham, tubular wells,	5.4
Cohasset, tubular wells No. 2,	5.6
Cohasset, tubular wells No. 1,	6.0
Williamstown, Sherman Spring,	6.4
Marblehead, Well No. 2,	6.8
Marblehead, Well No. 1,	7.0
Reading, filtered water,	8.8
Adams, tubular wells,	9.7
Williamstown, Cold Spring,	10.7
Amesbury, Market Street wells,	11.7

RESIDUE ON EVAPORATION IN GROUND WATERS.

The remarks concerning the presence of dissolved mineral matter in surface waters apply also to ground waters. The highest residues in unpolluted ground waters are found in the limestone regions and in wells near the sea, and the high total residue in other places is usually an indication of the previous pollution of the water by sewage. About half the ground waters of the State have a total residue of less than 6.5 parts per 100,000, and in 75 per cent. of the waters the total residue is less than 10 parts per 100,000. The total residue in the various ground-water supplies of the State is shown by the following table: —

Table No. 31. — *Residue on Evaporation in Ground Waters.*

[Parts per 100,000.]

Uxbridge, spring,	2.44
Shirley, well,	2.45
Mansfield, well,	2.72
Westborough, filter basin,	2.82
Winchendon, well,	3.05
Monson, well,	3.23
Sheffield, spring,	3.46
Foxborough, tubular wells,	3.58
Canton, Springdale well,	3.61
Avon, well,	3.70
Webster, well,	3.75
Holliston, well,	3.80
Medfield, spring,	3.85
Cottage City, springs,	3.89
Walpole, tubular wells,	3.92
Canton, well near Henry's Spring,	3.94
Attleborough, well,	4.02
Lowell, Boulevard wells (tubular),	4.16
Tisbury, spring,	4.25
Groton, well,	4.31
Easton, well,	4.43
Dracut, tubular wells,	4.60
Kingston, tubular wells,	4.60
Needham, Hicks Spring,	4.63
Braintree, filter-gallery,	5.09
Hingham, wells,	5.27
Ayer, well,	5.51
Needham, Well No. 1,	5.62
Newton, tubular wells and filter-gallery,	6.02
Millbury, well,	6.05
Newburyport, wells,	6.06
Leicester, wells,	6.11
Middleborough, well,	6.17
Needham, Well No. 2,	6.24
Fairhaven, tubular wells,	6.36
North Attleborough, well,	6.36
Franklin, wells,	6.43
Billerica, tubular wells,	6.50
Weston, well,	6.83
Bridgewater, wells,	6.91
Nantucket, wells,	7.00
Wellesley, filter-gallery,	7.00
West Springfield, well,	7.12
Waltham, well,	7.14
Millis, spring,	7.22
Methuen, tubular wells,	7.63
Wellesley, tubular wells,	7.63
Natick, well,	8.05
Framingham, filter-gallery,	8.17
Hyde Park, tubular wells near Mother Brook,	8.18
Ware, well,	8.19
Reading, filter-gallery,	8.33
Lowell, Cook wells (tubular),	8.86
Dedham, large well,	8.97
Brookline, tubular wells and filter-gallery,	9.02
Sharon, well,	9.26
Williamstown, Sherman Spring,	9.52
Wellesley, well at Williams Spring,	9.67
Woburn, filter-gallery,	9.68
Manchester, tubular wells,	9.73
Grafton, filter-gallery,	10.27
Amesbury, Main Street wells,	10.33
Hyde Park, tubular wells near the Neponset River,	10.37
Provincetown, well,	10.78
Cohasset, filter-gallery,	11.14
Manchester, large well,	11.15
Hopkinton, tubular wells,	11.52
Marshfield, well,	11.88
Williamstown, Cold Spring,	13.12
Cohasset, tubular wells No. 1,	13.24
Cohasset, tubular wells No. 2,	13.54
Adams, tubular wells,	13.60
Dedham, tubular wells,	13.97
Reading, filtered water,	15.26
Scituate, wells,	15.45
Marblehead, Well No. 1,	16.99
Marblehead, Well No. 2,	17.26
Amesbury, Market Street wells,	25.09

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

In the report for the year 1902, in the chapter entitled "Report upon the Examinations of the Outlets of Sewers and the Effect of Sewage Disposal in Massachusetts," the results of the investigation made in that year of the sources of pollution of streams in the State are presented in much detail, together with the results of analyses of the waters of these streams for a long series of years.

During the year 1904 the condition of the various streams has been observed as usual, but the flow of the streams during this year has not been low, and there has been no material change in the condition of the various polluted streams, so that the results of the examinations which have been made are not presented in detail.

Chemical analyses of samples of water from the following streams have been made at frequent intervals during the year: —

Blackstone.
Charles.
Merrimack.
Nashua.
Nemasket.
Neponset.
Quinepoxet.
Saugus.
Stillwater.
Sudbury.
Westfield.

The waters of the following streams have been examined during the summer months only: —

Assabet.
Chicopee.
Concord.
Connecticut.
Deerfield.
French.
Green.
Hoosick.
Housatonic.
Manhan.
Mill (Northampton).
Miller's.
Mumford.
Quaboag.
Quinebaug.
Rumford.
Salisbury Plain.
Seven Mile.
Shawsheen.
Spicket.
Taunton.
Ten Mile.
Three Mile.
Ware.

A summary of the various analyses, showing the condition of the Blackstone and Merrimack rivers at several points, is appended.

Blackstone River.

Chemical Examination of Water from the Blackstone River. — Averages for Six Months, from June to November, 1887 to 1904, inclusive.

Blackstone River, between Mill Brook Channel and the Sewage Precipitation Works of the City of Worcester.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation.		Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887,	0.91	–	–	.2686	.1741	–	–	1.35	.0160	–	–
“ “ 1888,	0.76	–	–	.2658	.1112	.0557	.0555	1.50	.0382	.0041	–
“ “ 1889,	0.86	–	–	.3980	.1430	.0772	.0658	1.32	.0177	.0026	–
“ “ 1890,	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
“ “ 1891,	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
“ “ 1892,	0.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
“ “ 1893,	0.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3
“ “ 1894,	0.66	16.93	4.76	.0548	.0380	.0236	.0144	0.74	.0115	.0005	4.4
“ “ 1895,	0.49	14.17	4.50	.0613	.0414	.0243	.0171	0.92	.0163	.0006	3.4
“ “ 1896,	0.51	12.90	2.93	.0780	.0415	.0282	.0133	0.97	.0147	.0015	3.4
“ “ 1897,	0.85	26.45	7.68	.1130	.0674	.0362	.0312	0.89	.0090	.0024	4.2
“ “ 1898,	0.33	17.42	5.62	.0857	.0619	.0260	.0359	0.96	.0053	.0010	4.6
“ “ 1899,	0.14	34.38	10.60	.2583	.0788	.0390	.0398	–	–	.0004	14.3
“ “ 1900,	0.05	16.48	3.38	.1068	.0518	.0210	.0308	1.03	.0107	.0012	3.6
“ “ 1901,	0.23	31.03	11.68	.1410	.0548	.0309	.0239	–	–	.0023	13.8
“ “ 1902,	0.10	46.15	12.47	.2453	.0728	.0274	.0454	–	–	.0010	16.5
“ “ 1903,	0.18	24.06	6.80	.2836	.0750	.0472	.0278	–	–	.0027	8.4
“ “ 1904,	0.12	44.68	17.08	.1228	.0434	.0225	.0209	–	–	.0008	14.7

Blackstone River, below Sewage Precipitation Works.

June-Nov., 1887,	0.91	–	–	.2686	.1741	–	–	1.35	.0160	–	–
“ “ 1888,	0.76	–	–	.2658	.1112	.0557	.0555	1.50	.0382	.0041	–
“ “ 1889,	0.86	–	–	.3980	.1430	.0772	.0658	1.32	.0177	.0026	–
“ “ 1890,	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
“ “ 1891,	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
“ “ 1892,	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
“ “ 1893,	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
“ “ 1894,	0.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
“ “ 1895,	0.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
“ “ 1896,	0.30	26.03	6.53	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
“ “ 1897,	0.73	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
“ “ 1898,	0.23	25.63	6.73	.3064	.0868	.0560	.0308	1.55	.0132	.0119	9.2
“ “ 1899,	0.14	44.02	9.67	.5251	.1707	.0912	.0795	3.26	.0108	.0068	16.1
“ “ 1900,	0.22	24.57	4.48	.4430	.1249	.0621	.0628	2.13	.0110	.0145	7.3
“ “ 1901,	0.09	31.12	6.90	.4580	.1293	.0772	.0521	3.42	.0090	.0058	10.8
“ “ 1902,	0.15	49.62	13.38	.7296	.1284	.0736	.0548	2.97	–	.0033	12.5
“ “ 1903,	0.39	31.08	9.48	.3880	.1080	.0545	.0535	–	–	.0062	10.4
“ “ 1904,	–	50.25	13.73	.6381	.1523	.0601	.0922	–	–	.0027	16.9

BLACKSTONE RIVER.

CHEMICAL EXAMINATION OF WATER FROM THE BLACKSTONE RIVER, ETC. — *Concluded.*

Blackstone River, at Uxbridge.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation.		Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887, . .	.39	–	–	.1129	.0271	–	–	0.79	.0360	–	–
" " 1888, . .	.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	–
" " 1889, . .	.32	–	–	.1133	.0296	.0192	.0104	0.66	.0333	.0009	–
" " 1890, . .	.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891, . .	.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892, . .	.13	9.36	1.88	.2840	.0227	.0162	.0065	0.99	.0313	.0007	3.1
" " 1893, . .	.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2
" " 1894, . .	.35	13.07	2.03	.1456	.0243	.0183	.0060	1.57	.0673	.0050	4.9
" " 1895, . .	.56	12.95	2.69	.0906	.0258	.0182	.0076	1.34	.0631	.0065	4.7
" " 1896, . .	.33	12.68	2.67	.1129	.0257	.0221	.0036	1.38	.0477	.0091	5.0
" " 1897, . .	.48	11.60	2.47	.1029	.0280	.0215	.0065	1.32	.0652	.0051	4.3
" " 1898, . .	.49	10.59	2.78	.0801	.0264	.0219	.0045	1.00	.0470	.0076	3.8
" " 1899, . .	.18	18.34	3.11	.2490	.0359	.0310	.0049	2.17	.0510	.0141	7.4
" " 1900, . .	.19	13.42	2.04	.2260	.0347	.0257	.0090	1.76	.0558	.0060	5.0
" " 1901, . .	.22	13.91	2.67	.3159	.0285	.0240	.0045	1.50	.0195	.0035	5.0
" " 1902, . .	.15	14.17	2.56	.3462	.0270	.0218	.0052	1.95	.0210	.0018	4.9
" " 1903, . .	.30	13.16	2.52	.3030	.0262	.0215	.0047	1.74	.0210	.0024	4.4
" " 1904, . .	.20	13.78	2.74	.2399	.0282	.0214	.0068	2.12	.0408	.0022	4.6

Blackstone River, at Millville.

Months.	Color.	Residue on Evaporation.		Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887, . .	.31	–	–	.0468	.0220	–	–	0.51	.0210	–	–
" " 1888, . .	.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	–
" " 1889, . .	.38	–	–	.0499	.0273	.0213	.0060	0.45	.0167	.0003	–
" " 1890, . .	.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891, . .	.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2
" " 1892, . .	.37	6.70	1.62	.1143	.0294	.0210	.0084	0.63	.0217	.0002	2.0
" " 1893, . .	.23	7.43	1.73	.0677	.0119	.0087	.0032	0.77	.0385	.0011	2.6
" " 1894, . .	.47	8.42	2.16	.0510	.0172	.0139	.0033	0.89	.0273	.0012	2.8
" " 1895, . .	.51	8.67	2.55	.0356	.0233	.0180	.0053	0.90	.0383	.0024	3.2
" " 1896, . .	.35	8.53	1.69	.0484	.0237	.0180	.0057	0.97	.0413	.0027	3.3
" " 1897, . .	.45	7.66	1.98	.0509	.0258	.0210	.0048	0.92	.0445	.0019	3.1
" " 1898, . .	.51	7.12	2.17	.0325	.0240	.0193	.0047	0.63	.0240	.0023	2.5
" " 1899, . .	.20	12.50	2.44	.1310	.0301	.0247	.0054	1.31	.0310	.0049	4.6
" " 1900, . .	.29	9.33	1.82	.1168	.0254	.0219	.0035	1.15	.0417	.0039	3.4
" " 1901, . .	.31	8.62	2.13	.1420	.0288	.0227	.0061	0.87	.0155	.0006	3.1
" " 1902, . .	.28	9.43	2.24	.1623	.0284	.0238	.0046	1.20	.0195	.0010	2.8
" " 1903, . .	.33	8.46	1.85	.1397	.0233	.0189	.0044	1.10	.0192	.0010	2.9
" " 1904, . .	.29	8.71	2.06	.1079	.0235	.0201	.0034	1.26	.0337	.0009	2.9

NOTE. — The sewage purification works of the city of Worcester were put in operation in 1890, since which time a portion of the sewage of the city has been treated. The works were enlarged in 1893, and since that time practically all of the dry-weather flow of sewage has been treated.

Merrimack River.

Table comparing the Analyses above Lowell with those above Lawrence, 1904.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
					Albuminoid.						
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	
Mean of analyses above Lowell, .	.30	4.25	1.77	.0072	.0191	.0146	.0045	.22	.0054	.0002	1.2
Mean of analyses above Lawrence, .	.32	4.56	1.83	.0164	.0238	.0172	.0066	.32	.0050	.0003	1.3
Increase, ...	.02	0.31	0.06	.0092	.0047	.0026	.0021	.10	.0004*	.0001	0.1

In order to compare these results with similar ones obtained in previous years, another table is presented, which shows the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years.

Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
					Albuminoid.						
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	
Increase, 1887-1889, .	0.01	0.23	0.09	.0007	.0027	.0017	.0010	.026	.0003*	.0000	–
Increase, 1890, . .	0.05	0.62	0.22*	.0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891, . .	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1
Increase, 1892, . .	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013*	.0000	0.0
Increase, 1893, . .	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002*	.0001	0.0
Increase, 1894, . .	0.02	0.15	0.04	.0028	.0032	.0032	.0000	.049	.0000	.0000	0.1
Increase, 1895, . .	0.11	0.52	0.33	.0022	.0063	.0046	.0017	.063	.0005	.0001	0.1
Increase, 1896, . .	0.02	0.51	0.24	.0034	.0053	.0047	.0006	.070	.0017	.0002	0.2
Increase, 1897, . .	0.06	0.30	0.08	.0019	.0051	.0033	.0018	.050	.0000	.0000	0.1
Increase, 1898, . .	0.03	0.37	0.07	.0024	.0039	.0019	.0020	.044	.0010	.0002	0.1
Increase, 1899, . .	0.02	0.39	0.07	.0038	.0045	.0023	.0022	.059	.0004*	.0001	0.1
Increase, 1900, . .	0.03	0.41	0.11	.0037	.0027	.0026	.0001	.055	.0011	.0000	0.0
Increase, 1901, . .	0.03	0.27	0.03	.0032	.0044	.0023	.0021	.053	.0020	.0003	0.3
Increase, 1902, . .	0.03	0.52	0.20	.0032	.0063	.0027	.0036	.060	.0000	.0001	0.1
Increase, 1903, . .	0.04	0.56	0.18	.0043	.0065	.0045	.0020	.072	.0014	.0002	0.2
Increase, 1904, . .	0.02	0.31	0.06	.0092	.0047	.0026	.0021	.100	.0004*	.0001	0.1

The average flow of the river at Lawrence, for twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,434, 8,126, 5,459, 11,634, 5,886, 8,230, 9,402, 7,406, 7,389, 8,524, 9,160, 9,674 and 7,410 cubic feet per second.

* Decrease.

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

WATER SUPPLY STATISTICS.

At the end of the year 1904 all of the 33 cities in Massachusetts and 147 of the 320 towns were provided with public water supplies. The following table gives a classification by population of the cities and towns having and not having public water supplies Dec. 31, 1904, the population being taken from the census of 1900: —

Population (1900).	Number of Places of Given Population having Public Water Supplies.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	-	-	37	13,383
500-999,	5	4,349	48	37,093
1,000-1,499,	13	16,167	34	41,262
1,500-1,999,	14	25,027	28	47,535
2,000-2,499,	12	26,560	12	26,872
2,500-2,999,	8	21,681	5	13,672
3,000-3,499,	11	35,221	2	6,817
3,500-3,999,	9	33,123	5	18,590
4,000-4,499,	7	29,878	1	4,364
4,500-4,999,	9	42,170	-	-
Above 5,000,	92	2,355,861	1	5,721
Totals,	180	2,590,037	173	215,309

All of the towns having a population, according to the census of 1900, in excess of 6,000 are supplied with water, and there are only 9 towns in the State which have a population in excess of 3,000 which are not provided with public water supplies. These towns are as follows: —

Town.	Population in 1900.	Town.	Population in 1900.
Blackstone,	5,721	Dartmouth,	3,669
Barnstable,	4,364	Dudley,	3,553
Chelmsford,	3,984	Templeton,	3,489
Pepperell,	3,701	Sutton,	3,328
Tewksbury,	3,683		

In all of the cities and 96 of the towns the water works are owned either by the municipality or by a fire or water supply district. In 51 towns the works are owned by private companies. The following table gives a classification by population of the cities and towns which own their water works and those which are supplied with water by private companies: —

POPULATION (1900).	Number of Places of Given Population owning Water Works.	Total Population of Places in Preceding Column.	Number of Places of Given Population supplied with Water by Private Companies.	Total Population of Places in Preceding Column.
Under 1,000,	3	2,623	2	1,726
1,000–1,999,	15	23,478	12	17,716
2,000–2,999,	10	23,731	10	24,510
3,000–3,999,	12	41,726	8	26,618
4,000–4,999,	13	58,302	3	13,746
5,000–5,999,	13	70,870	5	25,923
6,000–6,999,	6	38,778	1	6,058
7,000–7,999,	7	52,254	4	29,355
Above 8,000,	50	2,066,808	6	65,815
Totals,	129	2,378,570	51	211,467

NOTE. — Since Jan. 1, 1905, the ownership of the water works in Athol, population 7,061, Revere, population 10,395, and Tisbury, population 1,149, has changed from private to public; and the towns of Amesbury, population 9,473, Framingham, population 11,302, and Winthrop, population 6,058, have voted to take the works of the water companies in those places.

From the totals given in the above tables it will be seen that the population of those towns supplied with water by private companies is only 8.2 per cent. of the total population in all the cities and towns supplied with water, and that there are at the end of the year 1904 only 6 towns having a population above 8,000 which are supplied by private companies.

Records of the consumption of water are kept in nearly all of the cities and towns where water is pumped, and in several cities and towns Venturi meters are used to measure the quantity supplied. A summary of these statistics for the year 1904 is given in the following table. The estimated population given in the table is obtained by adding four-fifths of the increase in population from 1895 to 1900 to the population as determined by the census in the latter year. The daily consumption of water per inhabitant has been obtained by dividing the average daily consumption by the estimated population. The quantity obtained in this manner varies somewhat in the actual consumption per person using the water, as in many cities and towns there is a considerable number of people who do not use the public water supply, while in some of the towns used as summer resorts the population using the water during the summer months is much greater than the population shown by the census. With a few exceptions, however, the error is not large.

Statistics relating to the Consumption of Water in Various Cities and Towns.

CITY OR TOWN.	Estimated Population in **1904.**	Average Daily Consumption (Gallons), **1904.**	Daily Consumption per Inhabitant (Gallons), **1904.**	CITY OR TOWN.	Estimated Population in **1904.**	Average Daily Consumption (Gallons), **1904.**	Daily Consumption per Inhabitant (Gallons), **1904.**
Metropolitan Water District.*	928,770	113,922,000	123	Fairhaven, . .	3,750	336,000	90
Boston, . . .	611,830	87,680,000	143	Fall River, . .	117,391	4,092,000	35
Somerville, . .	70,320	6,228,000	89	Falmouth, . .	4,176	203,000	49
Malden, . .	40,825	1,868,000	46	Foxborough, . .	3,304	195,000	59
Chelsea, . .	37,835	4,260,000	113	Franklin, . . .	4,921	209,000	43
Everett, . .	29,370	2,624,000	89	Gardner, . . .	12,117	910,000	75
Quincy, . . .	27,830	2,823,000	101	Gloucester, . .	24,449	1,114,000	46
Medford, . .	22,125	1,803,000	81	Groton, . . .	1,940	57,000	29
Melrose, . .	14,445	1,525,000	106	Holliston, . . .	2,502	28,000	11
Revere, . . .	13,710	933,000	68	Hyde Park, . .	14,378	1,015,000	71
Watertown, . .	11,250	624,000	55	Ipswich, . . .	4,610	120,000	26
Arlington, . .	10,150	752,000	74	Lancaster, . .	2,718	73,000	27
Milton, . . .	7,740	316,000	41	Lawrence, . .	70,875	2,834,000	40
Winthrop, . .	7,770	742,000	96	Lincoln, . . .	1,140	162,000	142
Stoneham, . .	6,420	558,000	87	Lowell, . . .	103,451	5,485,000	53
Belmont, . .	5,045	249,000	49	Lynn and Saugus, .	78,993	5,333,000	67
Lexington, . .	3,620	283,000	78	Manchester, . .	3,039	279,000	92
Nahant, . . .	2,310	131,000	57	Mansfield, . .	4,234	187,000	44
Swampscott, . .	6,170	521,000	84	Marblehead, . .	7,511	552,000	73
Abington and Rockland.	9,884	431,000	44	Marlborough, . .	12,515	605,000	48
Andover, . . .	7,347	394,000	54	Maynard, . . .	3,182	276,000	87
Attleborough, . .	13,771	554,000	40	Methuen, . . .	8,970	313,000	35
Avon, . . .	1,833	78,000	43	Middleborough, .	7,042	255,000	36
Ayer, . . .	2,722	109,000	40	Milford and Hopedale.	15,963	872,000	55
Beverly, . . .	15,548	1,225,000	79	Millbury, . . .	3,851	187,000	49
Billerica, . . .	2,931	102,000	35	Montague, . .	6,224	577,000	93
Braintree, . .	6,517	592,000	91	Nantucket, . .	2,998	136,000	45
Bridgewater and East Bridgewater.	9,832	214,000	22	Natick, . . .	10,027	519,000	52
Brockton, . .	45,581	1,588,000	35	Needham, . .	4,420	274,000	62
Brookline, . .	22,952	2,348,000	102	New Bedford, . .	68,195	7,022,000	103
Cambridge, . .	100,080	8,847,000	88	Newburyport, . .	14,418	743,000	52
Canton, . . .	4,542	288,000	63	Newton, . . .	38,385	2,188,000	57
Clinton, . . .	15,403	532,000	35	North Andover, .	4,783	150,000	31
Danvers and Middleton.	9,671	787,000	81	North Attleborough,	7,795	300,000	38
Dedham, . . .	7,654	1,041,000	136	North Brookfield, .	4,547	151,000	33
Easton, . . .	5,145	125,000	24	Norwood, . . .	6,205	433,000	70

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* The figures given for the cities and towns in the Metropolitan Water District are taken from the report of the Metropolitan Water and Sewerage Board.

Statistics relating to the Consumption of Water in Various Cities and Towns — Concluded.

CITY OR TOWN.	Estimated Population in 1904.	Average Daily Consumption (Gallons), 1904.	Daily Consumption per Inhabitant (Gallons), 1904.
Orange, . . .	5,647	155,000	27
Peabody, . . .	12,335	1,666,000	135
Provincetown, . .	4,001	124,000	31
Randolph and Holbrook.	6,406	257,000	40
Reading, . . .	5,171	154,000	30
Rockport, . . .	4,036	327,000	81
Rutland, . . .	1,619	95,000	59
Salem, . . .	37,144	3,165,000	85
Sharon, . . .	2,336	79,000	34
Shirley, . . .	1,904	18,000	10
Stoughton, . .	5,578	365,000	65
Taunton, . . .	34,172	1,771,000	52
Tisbury, . . .	1,265	69,000	54
Wakefield, . .	10,079	655,000	65
Walpole, . . .	4,036	314,000	78
Waltham, . . .	25,565	2,073,000	81
Ware, . . .	8,753	350,000	40
Wareham, . .	3,484	32,000	9
Webster, . . .	9,608	305,000	32
Wellesley, . .	5,748	313,000	54
Weston, . . .	1,933	67,000	35
Whitman, . .	6,483	163,000	25
Winchendon, . .	5,409	98,000	18
Woburn, . . .	14,314	1,425,000	99
Worcester, . .	134,145	10,221,000	76

RAINFALL.

The average rainfall in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.49 inches. The average rainfall for the year 1904 in these places was 43.81 inches, making a deficiency of 1.68 inches. There was an excess of rainfall in January, April, June and September, and a deficiency during the remaining eight months. The greatest excess in any one month occurred in April, when the rainfall was 8.06 inches. The greatest deficiency occurred in October and November, when the rainfall was 1.78 and 1.83 inches respectively.

The following table gives the normal rainfall in the State for each month, as deduced from the observations at various places for a long period of years, together with the average rainfall at those places for each month during 1904, and the departures from the normal: —

MONTH.	Normal Rainfall (Inches).	Rainfall 1904 (Inches).	Excess or Deficiency 1904 (Inches).
January, . .	3.90	4.80	+0.90
February, . .	3.77	3.01	—0.76
March, . .	4.15	3.03	—1.12
April, . . .	3.60	8.06	+4.46
May, . . .	3.67	3.36	—0.31
June, . . .	3.28	3.49	+0.21
July, . . .	3.79	2.05	—1.74
August, . .	4.27	4.20	—0.07
September, . .	3.39	5.28	+1.89
October, . .	4.01	1.78	—2.23
November, . .	3.98	1.83	—2.15
December, . .	3.68	2.92	—0.76
Total, . .	45.49	43.81	—1.68

Flow of Streams.

The flow of streams for the year 1904, as indicated by the records of the Sudbury River, was less than the normal. The flow was in excess of the normal during the months of March, April, May and September, and below the normal during the remaining months. The greatest excess occurred in April and the greatest deficiency in February. In order to show the relation between the flow of the Sudbury River during each month of 1904 and the normal flow of that stream, as deduced from observations during thirty years, from 1875 to 1904, inclusive, the following table has been prepared. The area of the water-shed of the Sudbury River above the point of measurement is 75.2 square miles.

Month.	Normal Flow.		Actual Flow for **1904**.		Excess or Deficiency.	
	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.
January,	1.882	1.217	0.738	0.477	—1.144	—0.740
February,	2.879	1.861	1.365	0.882	—1.514	—0.979
March,	4.620	2.986	4.640	2.999	+0.020	+0.013
April,	3.273	2.116	5.096	3.294	+1.823	+1.178
May,	1.766	1.141	2.699	1.745	+0.933	+0.604
June,	0.807	0.522	0.648	0.419	—0.159	—0.103
July,	0.299	0.193	0.096	0.062	—0.203	—0.131
August,	0.450	0.291	0.262	0.170	—0.280	—0.121
September,	0.368	0.238	0.614	0.397	+0.246	+0.159
October,	0.327	0.506	0.295	0.191	—0.032	—0.315
November,	1.343	0.868	0.447	0.289	—0.896	—0.579
December,	1.675	1.082	0.417	0.269	—1.258	—0.813
	1.673	1.081	1.441	0.931	—0.232	—0.150

The next table shows the weekly fluctuation during 1904 in the flow of three streams which were carefully measured, namely, the Sudbury, the south branch of the Nashua and the Merrimack rivers. The flow of these streams, particularly the Sudbury and the south branch of the Nashua, serves to indicate the flow of other streams in eastern Massachusetts. The flow of the Merrimack River is affected to some extent by the diversion of water from two of its tributaries for the water supply of the metropolitan district. The quantity diverted in 1904 amounted to about 178 cubic feet per second, which would reduce the figures given for the flow per square mile of water-shed about .038 of a cubic foot per second. The water-shed of the Sudbury River is 75.2 square miles, of the Nashua 119 square miles, and of the Merrimack 4,664 square miles.

Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.			Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.		
	Sudbury River.	South Branch Nashua River.	Merrimack River.		Sudbury River.	South Branch Nashua River.	Merrimack River.
1904.				**1904.**			
Jan. 3,	0.602	0.944	0.668	July 3,	0.477	0.998	0.769
10,	0.777	0.806	0.563	10,	0.299	1.215	0.805
17,	0.954	0.974	0.588	17,	—0.094	0.527	0.549
24,	0.981	1.227	0.561	24,	—0.092	0.515	0.488
31,	0.262	1.184	0.583	31,	0.267	0.547	0.449
Feb. 7,	1.382	1.021	0.588	Aug. 7,	0.389	0.693	0.480
14,	0.331	0.687	0.564	14,	0.242	0.534	0.472
21,	1.099	0.679	0.544	21,	0.643	0.695	0.470
28,	2.564	2.958	0.764	28,	0.023	0.409	0.773
Mar. 6,	2.514	2.591	0.893	Sept. 4,	—0.016	0.181	0.452
13,	7.092	6.894	2.357	11,	0.022	0.278	0.404
20,	3.525	2.597	1.781	18,	1.725	1.966	0.810
27,	6.076	6.977	3.423	25,	0.557	0.471	0.711
Apr. 3,	4.251	4.412	5.330	Oct. 2,	0.425	0.584	0.855
10,	4.780	4.099	4.442	9,	0.083	0.436	0.739
17,	4.129	3.696	5.257	16,	0.428	0.471	0.611
24,	2.070	2.437	3.023	23,	0.587	0.728	0.732
May 1,	10.100	7.664	5.788	30,	0.436	0.564	0.931
8,	3.297	2.847	4.905	Nov. 6,	0.300	0.333	0.629
15,	3.331	2.497	3.099	13,	0.195	0.423	0.520
22,	2.462	2.367	4.124	20,	1.142	0.615	0.587
29,	1.077	1.458	2.527	27,	—0.335	0.681	0.587
June 5,	0.997	1.469	1.353	Dec. 4,	0.295	0.636	0.507
12,	1.161	2.103	1.405	11,	0.213	0.623	0.421
19,	0.292	0.865	0.895	18,	0.639	0.285	0.357
26,	0.384	0.565	0.621	25,	0.151	0.493	0.330

The following table gives the rainfall upon the Sudbury River water-shed and the total yield of the water-shed expressed in inches in depth on the water-shed (inches of rainfall collected) for the year 1904, together with the average of the records of thirty years, from 1875 to 1904, inclusive: —

Rainfall in Inches, received and collected on Sudbury Water-shed.

Month.	1904.			Mean for 30 Years. 1875-1904.		
	Rainfall.	Rainfall collected.	Per Cent. collected.	Rainfall.	Rainfall collected.	Per Cent. collected.
January,	4.87	0.851	17.5	4.21	2.170	51.6
February,	3.00	1.472	49.0	4.34	3.023	69.7
March,	2.72	5.349	196.8	4.59	5.326	116.0
April,	8.87	5.685	64.0	3.61	3.652	101.2
May,	2.65	3.112	117.7	3.34	2.036	60.9
June,	2.80	0.723	25.8	3.09	0.901	29.2
July,	1.96	0.111	5.6	3.67	0.345	9.4
August,	3.86	0.303	7.8	4.06	0.519	12.8
September,	5.80	0.685	11.8	3.32	0.411	12.4
October,	1.64	0.348	21.2	4.23	0.903	21.4
November,	1.73	0.499	28.8	3.96	1.500	37.9
December,	2.92	0.481	16.5	3.81	1.931	50.6
Totals and averages,	42.82	19.619	45.8	46.22	22.717	49.2

The Sudbury River records are particularly valuable as a basis for estimating the yield of other water-sheds in Massachusetts, both on account of the accuracy with which the measurements have been made, and the absence of abnormal conditions which would unfavorably affect the results.

The following table gives the records of the yield of this water-shed for each year of the past thirty years, the flow from the water-shed being expressed in gallons per day per square mile of water-shed, in order to render the table more convenient for use in estimating the probable yield of water-sheds used as sources of water supply: —

*Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile.**

Month.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000
Av. for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000
Av. for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000

Month.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
January,	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000	2,782,000
February,	2,403,000	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000	1,195,000
March,	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000	1,339,000
April,	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000	1,410,000
May,	1,292,000	938,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000	880,000
June,	529,000	300,000	417,000	426,000	203,000	414,000	422,000	653,000
July,	86,000	115,000	224,000	62,000	115,000	114,000	117,000	633,000
August,	55,000	78,000	257,000	240,000	94,000	214,000	380,000	1,432,000
September,	306,000	91,000	44,000	121,000	118,000	111,000	1,155,000	824,000
October,	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000	1,230,000
November,	210,000	205,000	175,000	1,178,000	673,000	368,000	2,758,000	1,941,000
December,	314,000	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000	2,241,000
Av. for whole year,	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000	1,383,000
Av. for driest six months,	211,000	145,000	200,000	391,000	223,000	234,000	953,000	944,000

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* The area of the Sudbury River water-shed used in making up these records included water surfaces amounting to about 2 per cent. of the whole area, from 1875 to 1878 inclusive, subsequently increasing by the construction of storage reservoirs to about 3 per cent. in 1879, to 3.5 per cent. in 1885, to 4 per cent. in 1894 and to 6.5 per cent. in 1898. The water-shed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile — Concluded.

MONTH.	**1890.**	**1891.**	**1892.**	**1893.**	**1894.**	**1895.**	**1896.**	**1897.**
January, ...	1,254,000	3,018,000	1,870,000	433,000	693,000	1,034,000	1,084,000	845,000
February, ...	1,529,000	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000	1,067,000
March, ...	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000	2,565,000
April, ...	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000	1,515,000
May, ...	1,366,000	582,000	1,259,000	2,883,000	840,000	636,000	360,000	915,000
June, ...	568,000	414,000	428,000	440,000	419,000	174,000	399,000	962,000
July, ...	108,000	149,000	214,000	158,000	161,000	231,000	95,000	658,000
August, ...	132,000	163,000	280,000	181,000	209,000	229,000	57,000	591,000
September, ...	458,000	203,000	229,000	108,000	150,000	89,000	388,000	182,000
October, ...	2,272,000	210,000	126,000	221,000	374,000	1,379,000	592,000	94,000
November, ...	1,215,000	305,000	697,000	319,000	836,000	2,777,000	659,000	909,000
December, ...	997,000	544,000	485,000	797,000	716,000	1,782,000	657,000	1,584,000
Av. for whole year, . .	1,285,000	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000	991,000
Av. for driest six months,	747,000	239,000	327,000	237,000	356,000	460,000	314,000	564,000

MONTH.	**1898.**	**1899.**	**1900.**	**1901.**	**1902.**	**1903.**	**1904.**	Mean for 30 Years, **1875** to **1904**, inclusive.
January, ...	1,638,000	2,288,000	794,000	437,000	1,763,000	1,736,000	477,000	1,217,000
February, ...	3,022,000	1,381,000	3,800,000	300,000	1,674,000	2,279,000	882,000	1,861,000
March, ...	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	3,454,000	2,999,000	2,986,000
April, ...	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,261,000	3,294,000	2,116,000
May, ...	1,246,000	511,000	1,312,000	2,954,000	743,000	351,000	1,745,000	1,141,000
June, ...	530,000	66,000	316,000	753,000	303,000	1,987,000	419,000	522,000
July, ...	231,000	19,000	—18,000	306,000	66,000	445,000	62,000	193,000
August, ...	1,107,000	—35,000	—34,000	424,000	135,000	307,000	170,000	291,000
September, ...	369,000	94,000	65,000	305,000	178,000	130,000	397,000	238,000
October, ...	1,160,000	115,000	186,000	412,000	506,000	492,000	191,000	506,000
November, ...	1,986,000	304,000	663,000	474,000	444,000	363,000	289,000	868,000
December, ...	1,799,000	220,000	1,096,000	2,695,000	1,779,000	582,000	269,000	1,082,000
Av. for whole year, . .	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,190,000	931,000	1,081,000
Av. for driest six months,	777,000	93,000	194,000	445,000	271,000	386,000	228,000	435,000

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1904.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.*

By H. W. CLARK, *Chemist of the Board.*

In the following report upon sewage purification the usual discussions in regard to the operation of the various sewage filters studied during the year are presented. Besides these discussions and the tables, showing the results of operation of these filters, various special studies made during the year are also described. These special studies have been as follows: —

1. Studies of the storage of nitrogen in and its removal from Filters Nos. 1 to 10, inclusive, together with details in regard to changes in management of these filters during the year to cause a reduction of stored nitrogen. Data are presented to show the results of these changes in removing nitrogen and also in improving the degree of purification of the applied sewage.

2. A comprehensive summary of the nitrogen-disposal efficiency of all the principal sand filters that have been operated at the station has been prepared, and tables showing this work are presented. These tables show the amount of nitrogen applied to these filters, the amount oxidized, the amount of unoxidized nitrogen appearing in the various effluents, the amount of nitrogen stored in the filters or unaccounted for, etc.

3. In connection with this study of the nitrogen stored and oxidized during the filtration of sewage, various special filters have been operated at the station during the year to learn as much as possible in regard to the removal, without interrupting filtration, of accumulated organic matter. In this study much has been learned in regard to the different nature of the organic matter stored in filters, the ease with which some of this matter is oxidized and nitrified, and the difficulty with which the remainder is oxidized

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* The work has been carried on under the general supervision of Hiram F. Mills, A.M., C.E., member of the State Board of Health, with the writer in direct charge. Mr. Stephen DeM. Gage and Mr. George O. Adams are the principal assistants of the writer at the station, and have aided in the preparation of this report. A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the purification of sewage and water, 1890. A similar account of the years 1890 and 1891 is contained in the twenty-third annual report of the Board for 1891. Since 1891 the results have been published yearly in the annual reports.

or removed by bacterial action. Some interesting figures are also presented showing, by means of ignition of the sand from the filters, the total amount of organic matter stored in Filters Nos. 1, 6 and 9A.

5. Studies of the different amounts of nitrogen lost in the operation of sewage filters of different kinds, — intermittent sand filters, contact filters and intermittent continuous or sprinkling filters; that is, a comparison of the amount of nitrogen applied to these filters with that appearing in their effluents.

6. A review of prolonged studies of the groups of bacteria found in Lawrence sewage and in the filters, and the influence of these various groups on the work of the filters, that is, upon the storage, oxidation, loss of and fixation of nitrogen. In connection with this, tables are presented showing by means of tests for B. coli the relative bacterial efficiency of the various kinds of filters.

7. Studies of the comparative value of Kjeldahl and albuminoid ammonia determinations of nitrogen in the examination of sewage and the effluents of sewage filters.

8. Studies of methods of making measurements by means of a new turbidity standard of the matter in suspension in and settling out from the effluents of sewage filters.

9. Studies of the rapidity of passage of sewage through intermittent-continuous or sprinkling filters, with ensuing purification.

10. Studies of septic tanks, etc.

ANALYSES OF SEWAGE.

The sewage used at the station comes through a 2½-inch pipe about 4,400 feet long. The matters in suspension in the sewage are well disintegrated by passage through this pipe. As received at the station it is a strong domestic sewage. The following tables present the result of the usual analyses of the various samples of sewage collected during the year: "Lawrence Street sewage" being the average of samples collected weekly from the sewer from which sewage is pumped to the station; "Regular station sewage" being the average of samples collected at the experiment station on at least four days of each week; "Sewage applied to Filters Nos. 1, 6 and 9A" being the average of samples collected from all sewage applied to these filters; and "Average sewage" being the average of all sewage pumped on each Tuesday of the year. Determinations of the total nitrogen and the nitrogen in solution have been made by the Kjeldahl method during the year in all of these samples with the exception of those collected from the sewage applied to Filters Nos. 1, 6 and 9A; in these the total nitrogen only was determined.

Lawrence Street Sewage.

[Parts per 100,000.]

1904.	Temperature (Deg. F.).	Ammonia.			Kjeldahl Nitrogen.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Albuminoid.								
		Free.	Total.	In Solution.	Total.	In Solution.		Nitrates.	Nitrites.		
January,	52	2.14	0.80	.54	3.10	1.99	9.82	.081	.0058	8.30	1,420,000
February,	51	2.60	1.05	.61	3.91	2.96	12.00	.124	.0068	9.04	2,025,000
March,	46	2.68	1.43	.82	3.61	1.77	8.36	.093	.0074	8.15	1,640,000
April,	50	2.23	0.91	.61	2.72	1.25	9.24	.103	.0065	6.84	3,158,000
May,	58	2.75	1.34	.54	3.28	1.62	13.40	.150	.0440	8.95	1,800,000
June,	65	1.95	0.80	.40	2.33	1.41	14.92	.174	.0110	7.91	1,035,000
July,	73	1.95	0.78	.46	2.29	1.59	14.10	.113	.0105	6.51	1,953,000
August,	74	2.16	0.93	.56	2.34	1.44	14.37	.111	.0143	8.99	4,310,000
September,	70	2.30	0.88	.55	2.34	1.65	9.82	.189	.0112	8.90	3,126,000
October,	66	2.78	0.99	.59	3.36	2.12	12.21	.093	.0113	9.24	2,518,000
November,	61	2.49	0.93	.58	2.59	2.03	9.99	.079	.0103	10.82	1,123,000
December,	58	3.25	1.09	.67	3.21	2.31	11.37	.088	.0117	14.45	2,223,000
Average,	60	2.44	0.99	.58	2.92	1.85	11.63	.117	.0126	9.01	2,194,000

Regular Station Sewage.

[Parts per 100,000.]

1904.	Temperature (Deg. F.).	Ammonia.			Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Albuminoid.						
		Free.	Total.	In Solution.	Total.	In Solution.			
January,	53	4.61	–	–	1.48	0.79	9.50	4.59	2,226,600
February,	49	4.79	–	–	1.77	0.91	8.27	5.11	1,772,000
March,	50	4.79	–	–	1.67	0.81	10.47	5.48	1,793,000
April,	51	5.59	–	–	1.79	0.89	10.27	4.75	2,105,000
May,	59	5.02	–	–	1.44	0.64	13.90	3.84	1,566,000
June,	65	4.89	–	–	1.37	0.57	14.93	4.37	1,503,000
July,	72	4.48	0.75	.35	1.21	0.54	15.44	4.24	1,248,800
August,	71	4.61	0.76	.34	1.33	0.55	16.39	4.49	1,438,300
September,	65	4.16	0.74	.35	1.22	0.54	11.74	3.98	1,360,700
October,	58	5.77	1.03	.49	2.06	0.94	14.15	5.37	2,476,000
November,	53	7.18	1.19	.58	2.73	1.20	13.07	5.56	3,022,000
December,	45	5.88	1.23	.71	3.92	2.06	9.59	6.54	2,616,000
Average,	58	5.15	0.95	.47	1.83	0.87	12.31	4.86	1,927,300

Sewage applied to Filters Nos. 1, 6 and 9A.

[Parts per 100,000.]

1904.	Temperature (Deg. F.).	Ammonia.		Kjeldahl Nitrogen.	Chlorine.	Oxygen Consumed.
		Free.	Total Albuminoid.			
January,	56	5.80	0.64	1.57	10.13	5.70
February,	59	4.87	1.03	1.79	9.12	6.23
March,	52	5.20	0.95	2.50	8.46	6.23
April,	54	5.42	0.81	1.82	11.78	5.60
May,	59	4.73	0.69	1.37	15.94	4.19
June,	65	4.88	0.70	1.26	17.26	4.41
July,	72	3.86	0.62	1.24	14.15	4.32
August,	71	3.83	0.63	1.26	16.02	3.99
September,	66	3.75	0.60	1.15	13.81	4.00
October,	60	5.13	0.79	1.76	13.77	5.19
November,	55	3.95	0.62	1.59	8.55	5.29
December,	58	3.07	0.55	1.54	5.74	4.45
Average,	61	4.54	0.72	1.57	12.06	4.97

Average Sewage.

[Parts per 100,000.]

1904.	Temperature (Deg. F.).	Ammonia.			Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Albuminoid.						
		Free.	Total.	In Solution.	Total.	In Solution.			
January,	57	4.90	–	–	1.59	0.80	10.20	4.95	2,753,000
February,	52	5.27	–	–	1.86	0.70	9.02	6.03	2,260,000
March,	52	4.38	–	–	1.62	0.89	11.40	5.64	2,270,000
April,	53	5.77	–	–	1.71	1.34	11.31	5.33	2,167,000
May,	60	5.06	–	–	1.53	0.68	14.20	4.19	2,016,000
June,	66	4.98	–	–	1.39	0.50	13.14	4.19	1,750,000
July,	73	4.78	0.80	.34	1.61	0.62	14.34	4.52	1,563,000
August,	71	4.08	0.66	.32	1.37	0.51	14.31	4.55	1,298,000
September,	67	3.97	0.79	.38	1.32	0.50	11.89	4.32	1,323,000
October,	62	6.60	1.28	.61	2.40	1.07	12.52	5.44	3,585,000
November,	53	6.76	1.28	.54	2.90	1.14	13.66	5.92	2,900,000
December,	45	4.90	0.87	.52	2.94	1.71	8.58	6.26	2,475,000
Average,	59	5.12	0.95	.45	1.85	0.87	12.05	5.11	2,197,000

NITROGEN STUDIES.

Storage of Nitrogen in and Removal from Filters Nos. 1, 2, 4, 6, 9A, 10, and Special Experiments bearing upon the Operation of these Filters.

Sand filtration is and for many years must remain the most important method of sewage purification in use in Massachusetts. Much attention is being given to the operation of the large sand filters at the experiment station, and studies are being made of everything affecting the permanency of these filters. From 1893 until the present time the filters have been so operated that it has not been necessary for purposes of sewage disposal to remove any sand from their upper layers, although considerable was removed during 1892 and 1893, after they had been in operation for five or six years. Notwithstanding the fact, however, that the surface sand during the years following 1893 has not become clogged to such an extent as to make its removal necessary in order that sewage may readily pass into the filters, enough organic matter has accumulated to gradually cause greater compactness, and because of this a more solid freezing of the upper 6 or 8 inches in depth of the sand in cold winter weather occurs than during the earlier years. The work of the filters in summer has been satisfactory, and good purification of the applied sewage has ensued, but during recent winters low nitrification and comparatively high free and albuminoid ammonia in the effluents have been the rule.

Special pains were taken to improve their work by breaking this compact layer in the fall of 1903 and so arranging the surface of Filters Nos. 1, 6 and 9A that the sewage, instead of being applied to the whole surface, was applied to a low area; that is to say, approximately 3 inches in depth of surface sand were removed from about two-thirds of the area of each of these filters and piled up on the remaining one-third of the area. On account of this arrangement of the surface, less ice formed upon the filters, frost entered less deeply, as shown by various examinations, and somewhat better nitrification was obtained than during several previous winters. The effluents, however, were not comparable in organic purity with the effluents obtained during earlier winters, when the filters had been in operation for a much shorter period and were receiving also much weaker sewage. Early in the spring of 1904, Filters Nos. 1, 6 and 9A were ridged and trenched, these trenches being about 10 inches deep. In Filters Nos. 2 and 4 — which for many years have contained trenches filled with coarse sand to which the sewage is applied — new trenches were dug, which were filled with clean, coarse sand. The old trenches of clogged and dirty sand were allowed to remain, but since the construction of the new trenches they have not had sewage applied to them.

The object of this surface arrangement was two-fold: (1) improved winter purification of sewage, and (2) to allow the disuse or resting of large portions of the upper sand in each filter in order that the organic matter stored upon this sand might be removed by bacterial oxidation. During the year frequent analyses have been made of the sand in order to learn if the nitrogen in the sand of the ridges was becoming less, and also to show the increase, if any, of nitrogen in the main body of the filter. As a result of this it has been learned that a portion of the stored organic matter in each filter is easily oxidized and nitrified under favorable conditions, but that there is a certain considerable percentage of more stable nitrogenous organic matter, which is very slowly acted upon by bacterial forces. From June 4 to September 1, the nitrogen in the sand of the ridges in Filter No. 1 decreased as follows, as shown by the analyses of samples collected : —

Decrease of Nitrogen in Sand of Filter No. 1.

[Parts per 100,000.]

Ridge No.	Albuminoid Ammonia.		Ridge No.	Albuminoid Ammonia.	
	June 4.	Sept. 1.		June 4.	Sept. 1.
1, ...	64.0	41.0	3, ...	87.0	51.0
2, ...	71.7	44.2	4, ...	75.0	48.0

Averaging these results we find that the albuminoid ammonia in the sand of the ridges decreased during these three months from an average of 74.4 parts to an average of 46.05 parts per 100,000, a decrease of 38 per cent. At the end of November, three months later, the average amount of nitrogen determined as albuminoid ammonia in the sand of ridges was 45.9 parts, that is, almost exactly the same as at the beginning of September, although the warm month of September and the comparatively warm months of October and November were favorable to bacterial action, and during these months the effluents of these filters were high in nitrates.

Decrease of Nitrogen in Filters Nos. 6, 9A and 10.

The ridges of Filter No. 6 contained, on June 8, 118.5 parts of albuminoid ammonia; on August 8, 65.2 parts, a decrease of 45 per cent.; and on November 18, an average of 67.8 parts, an apparent slight increase above that found on August 8, but this apparent increase was undoubtedly due to sampling and to the uneven distribution of nitrogen in the sand. The ridges of Filter No. 9A contained, on June 8, 62 parts albuminoid ammonia; on August 8, 55 parts, a decrease of 10 per cent. only; and an examination on November 15 showed no further decrease.

On June 3, 1904, 8 inches in depth of surface sand from Filter No. 10 were removed and piled in a thin layer by the side of the filter, analyses being made from time to time, dates of examination and results of these analyses being as follows, and showing a decrease of the nitrogen determined as albuminoid ammonia of about 50 per cent. in four months : —

Decrease of Nitrogen in Sand of Filter No 10.

[Parts per 100,000.]

	Albuminoid Ammonia.		Albuminoid Ammonia.
June 3,	195.0	August 17,	114.0
June 15,	104.0	August 29,	114.0
July 20,	109.0	October 12,	96.0

Sub-surface Nitrogen.

The following table gives the amount of nitrogen determined as albuminoid ammonia found at different depths below the surface ridges in Filter No. 1 upon Nov. 23, 1903, and Oct. 10, 1904 : —

Determinations of Nitrogen in Sand of Filter No. 1.

[Parts per 100,000.]

Depth.	Albuminoid Ammonia.		Depth.	Albuminoid Ammonia.	
	Nov. 23, 1903.	Oct. 10, 1904.		Nov. 23, 1903.	Oct. 10, 1904.
6 inches,	46.3	47.0	24 inches,	7.2	9.2
9 inches,	58.5	45.1	36 inches,	4.9	6.3
12 inches,	18.2	39.0	48 inches,	3.3	5.0
15 inches,	13.6	14.0	60 inches,	4.6	3.4
18 inches,	16.8	11.9			

Studying this table it will be seen that there was only a slight increase of stored nitrogen during the year 1904 in the main body of this filter. A similar table, showing the amount of nitrogen stored below the surface ridges in Filter No. 9A, Nov. 30, 1903, and Oct. 12, 1904, follows : —

Determinations of Nitrogen in Sand of Filter No. 9A.

[Parts per 100,000.]

Depth.	Albuminoid Ammonia.		Depth.	Albuminoid Ammonia.	
	Nov. 30, 1903.	Oct. 12, 1904.		Nov. 30, 1903.	Oct. 12, 1904.
6 inches,	50.0	59.4	24 inches,	6.2	6.5
9 inches,	39.5	52.8	36 inches,	3.9	6.0
12 inches,	11.5	47.6	48 inches,	3.6	4.7
15 inches,	8.9	29.7	60 inches,	3.1	4.1
18 inches,	6.7	15.5			

These figures show a considerable increase in the nitrogen stored in the filter towards the end of 1904 above that stored towards the end of 1903; but analyses of samples from the different depths in previous years have shown a considerable fluctuation in the amount of nitrogen present at these depths from season to season and from year to year.

Special Studies upon Nitrification and Removal of Nitrogen by Means of Filters constructed of Surface Sand from Filters Nos. 1, 6 and 9A, etc.

During the year five small filters, Nos. 265, 266, 267, 268 and 269, respectively, have been operated for further study of the removal of organic matter from clogged sand. These filters were placed in the laboratory and were started early in May. Each contained 1 foot in depth of sand. Filter No. 265 was constructed of surface sand from Filter No. 1, Filter No. 266 of surface sand from Filter No. 6, Filter No. 267 of surface sand from Filter No. 9A, Filter No. 268 of surface sand from the sewage disposal area at Clinton, Mass., and Filter No. 269 was constructed of fresh clean sand. Each of these filters was flooded with water, and the rate of operation of each was 30,000 gallons per acre daily. The sand in Filter No. 265 contained at the beginning of the experiment 144.7 parts of albuminoid ammonia; the sand in Filter No. 266, 118.5 parts of albuminoid ammonia; the sand in Filter No. 267, 59.3 parts albuminoid ammonia; and the sand in Filter No. 268, 61.3 parts albuminoid ammonia per 100,000. Tables showing the results of analyses of effluents of these filters are given below.

Nitrification started immediately in Filter No. 265, containing sand from Filter No. 1, and at the end of a week of operation the effluent of this filter contained 15 parts of nitrates per 100,000. In Filter No. 266 nitrification also started immediately, but was not so intense as in Filter No. 265. However, at the end of a week the effluent of this filter contained over 5 parts of nitrates per 100,000. In Filter No. 267, containing the finer sand from Filter No. 9A, nitrification did not become particularly active until a month had elapsed, when its effluent contained 3.5 parts of nitrates per 100,000, this being the maximum amount reached during the operation of this filter. Filter No. 268, constructed of sand from the Clinton area, was very irregular in its action, nitrification beginning immediately, but changing quickly from high to low nitrification and *vice versa*. Results similar to these are obtained at the Clinton area.

The particularly noticeable fact learned by the operation of these filters was that, from each sand, a large amount of the stored nitrogenous organic matter was removed at the end of two months of operation, but at the end of seven months but little further removal had occurred; that is to say, — as shown also by the experiment in ridging and trenching Filters Nos. 1, 6 and 9A, — much of the stored organic matter was easily oxidized, but there was a residual amount of stable organic matter stored upon the sand that was very slowly changed by bacterial action. During the entire period of operation, even after nitrogen removal had practically ceased, some nitrification was occurring in the filters, and conditions were favorable for nitrogen removal, as the filters, being in the laboratory, were always warm.

The reduction of nitrogen in the sand of Filter No. 265 in two months, as shown by albuminoid ammonia determinations, was from 144.7 to 42.7 parts per 100,000 of albuminoid ammonia, or 70.5 per cent.; but at the end of four months and eight months the amount found in the sand was still 42 and 43 parts, respectively, although throughout this latter period nitrates averaging 0.5 part per 100,000 were found in the effluent of this filter, as shown in a following table.

Practically the same results were given by Filters Nos. 266, 267 and 268. A reduction in albuminoid ammonia in the sand in Filter No. 266 from 118.5 to 53 parts per 100,000, or 55 per cent., occurred in two months, and at the end of eight months of operation there were still 53 parts of albuminoid ammonia present in this sand, although the effluent had continued to contain nitrates in considerable amounts. Filter No. 267 showed a reduction from 59 to 41 parts per 100,000, or 30 per cent., in two months, and at the end of eight months no further decrease had occurred. Filter No. 268 showed a reduction from 61 parts to 43 parts per 100,000, or 30 per cent., at the end of two months, and at the end of four and eight months 43 and 35 parts of albuminoid ammonia per 100,000 were found, respectively.

The following tables show the actual amount of nitrogen removed from the sand of each filter, as shown by analyses of the sand, and found present in the effluents, as shown by analyses of these effluents, as free ammonia, nitrates and nitrites. It will be seen that the amount found in the effluent of Filter No. 265 was only about 18 per cent. of the total amount removed; with Filter No. 266 the amount of nitrogen accounted for in this way was 23 per cent. of the total amount removed, and with Filter No. 267, 71 per cent., these results showing that much nitrogen escaped into the air as the result of the work of nitrogen-liberating bacteria undoubtedly present in large numbers in each filter.

Tables showing the Amount of Nitrogen in the Sand of Filters Nos. 265, 266, 267 and 268 at Different Periods and the Amount of Nitrogen appearing in the Effluents.

Total Nitrogen, in Grams, in the Sand of Filters Nos. 265, 266, 267 and 268 at Different Periods of Operation.

1904-1905.	Filter No. 265.	Filter No. 266.	Filter No. 267.	Filter No. 268.
Beginning of operation,	1.780	1.080	.576	.662
July 26,	0.525	0.480	.402	.460
August 29,	0.518	0.432	.415	.464
December 15,	0.527	0.482	.449	.378
March 1,	0.521	0.407	–	.382

Tables showing the Amount of Nitrogen in the Sand of Filters Nos. 265, 266, 267 and 268 at Different Periods and the Amount of Nitrogen appearing in the Effluents — Concluded.

Amount of Nitrogen, in Grams, removed from Filters Nos. 265, 266, 267 and 268, and appearing in their Effluents as Free Ammonia, Nitrates and Nitrites.

1904-1905.	Filter No. 265.	Filter No. 266.	Filter No. 267.	Filter No. 268.
May,	.055	.012	.062	.006
June,	.082	.045	.023	.019
July,	.038	.035	.023	.014
August,	.017	.017	.004	.003
September,	.012	.011	.002	.005
October,	.009	.006	.002	.004
November,	.009	.005	.002	.004
December,	.007	.004	.003	.003
January,	.005	.003	.003	.003
Total,	.234	.138	.124	.061

Various efforts were made, after removal of nitrogen had practically ceased, to cause a more rapid oxidation of the stable organic matter in these filters, that is, to increase nitrification. Lime, potassium carbonate, sodium chloride, hydrochloric acid in minute amounts, etc., were experimented with and added to the sewage at different times in order to cause, if possible, increased activity of the nitrifying organisms, but these efforts were not successful. River water was also used in order to be sure that the nitrifying organism was passed to each filter, and finally river water containing 1 per cent. of sewage. Cultures of bacteria were also introduced. All this was without effect, however, and while nitrification remained comparatively uniform in several of these filters, it was low, notwithstanding the large amount of organic matter remaining upon the sand.*

Conclusions.

All this work upon the removal of organic matter has clearly shown that by systematic resting of large amounts of the upper sand of sewage filters a considerable percentage of the nitrogenous organic matter can be removed by bacterial means, especially when the filters have been in use for many years and the organic matter accumulated upon this sand has undergone long-continued bacterial working over; but it has also clearly shown the stable nature of a large percentage of this organic matter. Undoubtedly, however, a portion of the stable organic matter now present on the sand will, in the course of time, become of a nature as easily oxidized as that shown to be readily oxidized during the past year, but a portion is probably as stable as humus. In other words it is stable as soil nitrogen which remains year after year at practically the same point unless exhausted by severe cropping. It is part of the residual organic matter remaining after that easily changed has been removed by bacterial action. With the constant accumulation, caused by regular application of sewage, it will be difficult to lessen the actual amount of this residual matter present in the entire body of the filter; that is to say, while ridging will allow the resting of a portion of the sand, this ridging renders it necessary to apply the sewage to lower depths of the filter, and the consequent more rapid accumulation of organic matter at these depths than would otherwise occur.

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* During 1905 it has been proved that if easily nitrified but sterile nitrogen is added to these filters, nitrification will become active within them, but practically ceases again when this easily nitrified nitrogen is exhausted. This will be discussed in a future report.

Tables of Analyses of Effluents of Filters Nos. 265, 266, 267, 268 and 269.

Filter No. 265.

Constructed of 1 foot of sand from the surface of Filter No. 1. Flooded daily with water at the rate of 30,000 gallons per acre daily. Effluent clear. The albuminoid ammonia of this sand at the start was 144.7 parts per 100,000 parts, and after being flooded sixty times was 42.7 parts.

Average Analyses.

[Parts per 100,000.]

1904.	Free Ammonia.	Nitrogen as		Alkalinity by	
		Nitrates.	Nitrites.	Methyl-Orange.	Gallein.
May 20,	1.2500	5.89	.1000	–	–
May 21,	1.1750	1.40	.0300	–	–
May 23,	1.9000	5.40	.0600	–	–
May 24,	1.6000	8.32	.0800	–	–
May 26,	0.7500	12.18	.0150	–	–
May 28,	0.1300	15.10	.0040	–	–
May 31,	0.0600	15.53	.0240	1.0	–
June,	0.0500	5.93	.0030	0.5	–
July,	0.0150	2.75	.0018	—0.6	—0.7
August,	0.0100	1.17	.0000	—0.7	—0.2
September,	0.0275	0.71	.0002	0.4	0.4
October,	0.0480	0.63	.0004	0.5	0.5
November,	0.0360	0.65	.0002	0.3	0.3
December,	0.0250	0.45	.0010	0.3	0.3

October 27, mixed water cultures of bacteria with ammonifying, denitrifying and nitrogen liberating power applied. Beginning December 16 filter flooded with river water.

Filter No. 266.

Constructed of 1 foot of sand from the surface of Filter No. 6. Flooded daily with water at the rate of 30,000 gallons per acre daily. Effluent clear. The albuminoid ammonia of this sand at the start was 118.5 parts per 100,000 parts. Albuminoid ammonia after being flooded sixty times was 52.8 parts.

Average Analyses.

[Parts per 100,000.]

1904.	Free Ammonia.	Nitrogen as		Alkalinity by	
		Nitrates.	Nitrites.	Methyl-Orange.	Gallein.
May 20,	.9500	0.63	.0900	–	–
May 21,	.9400	1.40	.0300	–	–
May 23,	.1800	2.25	.0200	–	–
May 24,	.2600	1.82	.0300	–	–
May 26,	.1500	1.68	.0000	–	–
May 28,	.0600	5.05	.0020	–	–
May 31,	.0800	1.26	.0020	0.7	–
June,	.0567	3.19	.0000	—0.4	–
July,	.0675	2.50	.0018	—0.7	—0.4
August,	.0200	1.21	.0002	—0.5	—0.4
September,	.0225	0.77	.0000	0.3	0.3
October,	.0333	0.42	.0005	0.8	0.8
November,	.0180	0.35	.0006	0.5	0.5
December,	.0300	0.27	.0025	0.6	0.6

Beginning Oct. 27, 1904, Filter No. 266 flooded with solution of 5 parts chlorine as sodium chloride. December 7 discontinued flooding filter with sodium chloride. Began flooding with distilled water. Beginning December 16 filter flooded with river water.

Filter No. 267.

Constructed of 1 foot of sand from the surface of Filter No. 9A. Flooded daily with water at a rate of 30,000 gallons per acre daily. Effluent was turbid and colored with iron until June 7, when it became clear. The albuminoid ammonia of this sand at the start was 59.3 parts per 100,000 parts, and after being flooded sixty times was 41.3 parts.

Average Analyses.

[Parts per 100,000.]

1904.	Free Ammonia.	Nitrogen as		Alkalinity by	
		Nitrates.	Nitrites.	Methyl-Orange.	Gallein.
May,	5.2000	0.21	.0300	14.8	–
June,	0.4475	1.29	.0193	3.8	–
July,	0.0500	1.65	.0010	—3.1	—2.0
August,	0.0760	0.20	.0002	1.0	0.8
September,	0.0263	0.14	.0000	2.1	1.9
October,	0.0283	0.10	.0007	2.0	1.9
November,	0.0180	0.14	.0004	1.7	1.7
December,	0.0300	0.18	.0005	1.0	1.0

Beginning Oct. 27, 1904, Filter No. 267 flooded with a solution of 4.4 parts potassium carbonate. December 7 discontinued flooding filter with potassium carbonate solution and began flooding with distilled water. Beginning December 16 filter flooded with river water.

Filter No. 268.

Constructed of 1 foot of sand from the Clinton sewage-disposal area. Flooded with water at rate of 30,000 gallons per acre daily. Effluent clear. The albuminoid ammonia of this sand at the start was 61.33 parts per 100,000 parts, and after being flooded fifty-three times was 42.70 parts.

Average Analyses.

[Parts per 100,000.]

1904.	Free Ammonia.	Nitrogen as		Alkalinity by	
		Nitrates.	Nitrites.	Methyl-Orange.	Gallein.
May,	.0967	5.14	.0087	0.4	-
June,	.0600	1.31	.0010	1.1	-
July,	.0325	1.02	.0025	1.6	1.2
August,	.0200	0.22	.0022	1.3	0.7
September,	.0213	0.37	.0003	1.7	1.6
October,	.0400	0.24	.0013	1.0	0.9
November,	.0420	0.24	.0010	0.5	0.5
December,	.0350	0.22	.0005	0.8	0.7

Beginning Oct. 27, 1904, Filter No. 268 flooded with a solution of 1.2 parts hydrochloric acid. December 7 discontinued flooding with hydrochloric acid solution and began flooding with distilled water. Beginning December 16 filter flooded with river water.

Filter No. 269.

Constructed of 1 foot of clean sand. Flooded with regular sewage at rate of 30,000 gallons per acre daily.

Average Analyses.

[Parts per 100,000.]

1904.	Free Ammonia.	Nitrogen as		Alkalinity by	
		Nitrates.	Nitrites.	Methyl-Orange.	Gallein.
July,	0.5350	3.09	.0775	-	-
August,	0.2680	2.63	.1574	3.1	2.7
September,	0.3650	2.56	.0173	1.0	0.8
October,	1.5933	2.93	.0050	1.4	1.4
November,	2.7367	2.50	.0153	2.0	1.9
December,	1.8250	7.47	.0150	0.1	—0.5

A Study of the Work accomplished by Sand Filters in the Disposal of Nitrogen, including Figures showing Nitrogen applied, Nitrogen oxidized, Nitrogen not appearing in the Effluent, Nitrogen stored in the Sand, etc.

In the purification of sewage by sand filtration good nitrification must ensue if a purified effluent is to be obtained and the filters be reasonably permanent, that is, suitable to accomplish good work year after year. This is especially so if the filters are operated in a manner similar to that followed at the experiment station, as at the station no solid matter strained out from the sewage by the filter is removed from the surface of the filter; and, in fact, with sewage of the character of that at the station, practically all matters pass below the surface of the sand. At many of the filtration areas in the State, however, which receive fresh sewage containing much organic matter only slightly disintegrated, a large amount of material strains out upon and is removed from the surface of the filter beds or is settled out and passed to sludge beds; and this removal lessens the work that must be accomplished by the filter itself, as a smaller amount of organic matter has to be oxidized or nitrified within the body of the filter. The Lawrence Experiment Station sewage contains as much suspended organic matter as most of the sewages of the towns and cities of the State having filtration areas, but as this matter is very finely divided and largely passes into the upper layers of sand in the filters, nitrification must average much greater than at the municipal areas. A comparison of the per cent. of oxidized nitrogen present in the effluents of the Lawrence filters and in the effluents of the municipal filters shows the truth of this statement. (For tables see pages 212 to 216, inclusive, and page 224.)

A study of the percentage of the actual amount of nitrogen applied to Lawrence sand filters that appears in their effluents (1) in an oxidized condition, (2) in an unoxidized condition and (3) of the percentage of the applied nitrogen removed by the filter, etc., has been made, and the results obtained are given in following tables. It is evident from this study that the average amount of the applied nitrogen that is nitrified while the sewage is passing through the Lawrence filters is between 50 and 55 per cent. These tables also show clearly that when the sand filters at Lawrence were first put into operation the percentage of nitrogen nitrified in the filter was generally much smaller than when the filter had been better seeded with nitrifying organisms. During the first year or two of operation, also, a very much larger percentage of the applied nitrogen was stored in the filter than during subsequent years, and hence a smaller percentage of unoxidized nitrogen appeared in the effluents of these filters than during subsequent years. For example, Filter No. 1, during its first year of operation, as shown in a following table, stored or otherwise removed from the applied sewage 63 per cent. of its nitrogen, that is to say, only 37 per cent. of the nitrogen applied appeared oxidized and unoxidized in the filter effluent. With Filter No. 2, 68 per cent. of the nitrogen applied during the first year of operation and 58 per cent. of the nitrogen applied during the second year of operation did not appear in the effluent of the filter. With Filter No. 4. 81 per cent. of the nitrogen applied during the first year and 75 per cent. of that applied during the second year did not appear in the effluent of the filter. With Filter No. 6, 70 per cent. of the nitrogen applied during the first year did not appear in the filter effluent, and with Filter No. 9A, 75 per cent. of the nitrogen applied during the first year did not appear in its effluent. Taking, however, the entire series of years of operation of these filters up to the end of 1904, the average amount of the applied nitrogen not appearing in the effluents has been 28 per cent. for Filter No. 1, 35 per cent. for Filter No. 2, 46 per cent. for Filter No. 4, 34 per cent. for Filter No. 6, and 29 per cent. for Filter No. 9A.

During the first years of operation of these filters the average percentage of the applied nitrogen that appeared as nitrates in the effluents was considerably less than during subsequent years, as shown by the tables. For instance, during the first full calendar year of operation of Filter No. 2 the percentage of the applied nitrogen appearing as nitrates in its effluent was 41, although the average for the entire period of operation up to the end of 1904 has been nearly 53. The nitrates for the first full year of operation of Filter No. 4 contained 23.6 per cent. of the applied nitrogen, while the average for the entire period up to date is 48 per cent., and similar figures are shown by the other sand filters studied.

As the filters became older, that is, as they were continued in use year after year, the percentage of applied nitrogen appearing as nitrates increased. In different years from 65 to 77 per cent. of the applied nitrogen appeared as nitrates in the filter effluent, high nitrification following the rejuvenating of Filters Nos. 1, 6 and 9A in 1893, the year when clogged surface sand was last removed. Notwithstanding this increase in nitrification, however, there was a considerable increase year after year in the amount of unoxidized nitrogen appearing in the effluents, this fact being probably in a large measure accounted for by the increased strength of the sewage, that is, a larger amount of nitrogen was applied to the filters each year. In each of the tables following, giving the nitrogen results of this study of the various filters, are columns showing the average nitrogen in parts per 100,000 in the applied sewage, and also the "units" of applied nitrogen, the "units" being obtained by multiplying the average parts of nitrogen per 100,000 in the applied sewage by the rate of operation of each filter in thousand gallons per acre daily.

Summarizing this work the following conclusions can be drawn: —

1. With new sand filters a smaller percentage of the applied nitrogen appears in the effluent than when the filters have been operated for a considerable period.

2. With filters producing eminently satisfactory purification, as Filters Nos. 2 and 4, during many of the years included in the table, the average amount of nitrogen appearing in the effluents as nitrates is but little more than 50 per cent. of the nitrogen in the applied sewage.

3. This being so, it is clear that, if a filter is not ultimately clogged by stored nitrogenous organic matter, either removal of this matter must be resorted to, together with a removal of some of the filtering material, or a removal by bacterial actions independent of and differing from those of nitrification must be depended upon.

4. Much of the increase of unoxidized nitrogen in the effluent of the sand filters has been due to the increase of applied nitrogen year by year and the accumulation of stable organic matter in the filter.

On account of the application of this larger amount of nitrogen two results ensue: (1) an amount of nitrogen in solution greater than can be easily and completely changed by bacterial action during the period of passage of the sewage through the filter, and (2) an amount of stable organic matter in suspension in the sewage is strained out and, accumulating in the upper sand of each filter, causes unfavorable conditions, especially in winter, on account of the resultant increased compactness of these upper layers.

Differing bacterial flora in the filter due to increase in stored organic matter and continued use of the filter may also be an important factor.

FILTER NO. 1.—*Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Sewage for Filter No. 1."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1888,*	53.4	2.70	144	63.0	29.6	7.4
1889,	63.6	2.71	172	40.9	55.4	3.7
1890,	84.2	2.92	246	47.0	46.5	6.5
1891,	115.8	3.32	383	51.1	39.6	9.3
1892,	124.1	3.78	469	48.2	40.7	11.1
1893,	105.9	3.66	389	23.3	58.7	18.0
1894,	70.3	4.47	314	17.0	71.1	11.9
1895,	67.4	4.06	274	9.4	68.5	22.1
1896,	56.8	4.81	273	28.6	63.1	8.3
1897,	62.1	4.95	308	33.1	55.0	11.9
1898,	60.5	4.29	259	27.8	62.0	10.2
1899,	54.8	4.32	237	27.1	59.5	13.4
1900,	51.9	4.95	257	31.7	55.3	13.0
1901,	57.2	5.40	309	24.8	34.8	40.4
1902,	56.6	4.95	280	18.6	45.0	36.4
1903,	72.0	4.84	349	8.7	58.1	33.2
1904,	54.9	6.11	336	21.2	54.6	24.2
Average,	71.3	4.25	303	28.5	53.4	18.1

* Filter started Jan. 10, 1888.

Filter No. 2.— *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Sewage for Filter No. 1."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
		Parts per 100,000.	Units.	Not appearing in Effluent.	IN EFFLUENT.	
					Oxidized.	Un-oxidized.
1888,*	28.2	2.70	76	68.5	25.2	6.3
1889, ...	32.0	2.71	87	58.3	40.6	1.1
1890, ...	59.6	2.92	174	43.2	55.8	1.0
1891, ...	50.8	3.32	169	59.0	31.8	9.2
1892, ...	24.5	3.78	93	47.9	38.4	13.7
1893, ...	40.3	3.66	147	24.9	67.5	7.6
1894, ...	43.9	4.47	196	33.0	63.9	3.1
1895, ...	33.7	4.06	137	21.0	66.0	13.0
1896, ...	37.0	4.81	178	25.0	68.1	6.9
1897, ...	37.0	4.95	183	46.5	49.3	4.2
1898, ...	38.3	4.29	164	41.8	53.8	4.4
1899, ...	34.4	4.32	149	40.0	51.2	8.8
1900, ...	33.8	4.95	167	25.7	67.0	7.3
1901, ...	36.3	5.40	196	33.4	44.8	21.8
1902, ...	31.2	4.95	154	18.7	53.7	27.6
1903, ...	34.7	4.84	168	9.3	66.5	24.2
1904, ...	32.6	6.11	199	35.6	38.1	26.3
Average, ...	37.0	4.25	157	35.2	52.6	12.2

* Filter started Dec. 19, 1887.

Filter No. 4.— *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Average Sewage for Filters Nos. 1, 6 and 9A."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
		Parts per 100,000.	Units.	Not appearing in Effluent.	IN EFFLUENT.	
					Oxidized.	Un-oxidized.
1888,*	28.7	2.70	76	80.8	8.1	11.1
1889, ...	20.0	2.71	54	75.3	23.6	1.1
1890, ...	33.2	2.92	97	55.8	43.5	0.7
1891, ...	41.4	3.32	137	53.3	43.6	3.1
1892, ...	41.8	3.87	162	68.7	17.6	13.7
1893, ...	32.3	3.81	123	58.8	38.0	3.2
1894, ...	20.1	4.47	90	56.0	34.2	9.8
1895, ...	15.8	4.60	73	53.5	44.8	1.7
1896, ...	19.0	5.01	95	39.7	55.5	4.8
1897, ...	19.4	5.01	97	39.3	58.5	2.2
1898, ...	19.3	4.30	83	46.0	52.8	1.2
1899, ...	16.8	4.01	68	46.7	51.1	2.2
1900, ...	17.8	5.06	90	33.9	64.5	1.6
1901, ...	20.4	5.50	112	41.3	49.8	8.9
1902, ...	19.6	4.95	97	14.6	62.2	23.2
1903, ...	18.2	4.84	88	30.1	64.1	5.8
1904, ...	18.0	6.11	110	39.3	56.3	4.4
Average, ...	23.6	4.31	102	46.4	47.8	5.8

* Filter started Dec. 19, 1887.

Filter No. 5A. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Average Sewage for Filters Nos. 1, 6 and 9A."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	Nitrogen applied.		Per Cent. of Applied Nitrogen.		
		Parts per 100,000.	Units.	Not appearing in Effluent.	In effluent.	
					Oxidized.	Un-oxidized.
1891,*	64.0	5.15	330	76.2	17.2	6.6
1892,	94.4	3.87	366	48.1	30.2	21.7
1893,	119.2	3.81	454	32.6	48.0	19.4
1894,	90.6	4.47	405	23.7	60.6	15.7
1895,	68.3	4.60	314	23.1	54.1	22.8
1896,	56.1	5.01	281	16.3	61.9	21.8
1897,	58.8	5.01	295	26.3	54.8	18.9
1898,†	83.2	4.10	341	36.6	28.5	34.9
Average,	79.3	4.50	357	35.5	44.7	19.8

* Filter started Sept. 14, 1891.

† Two months, January and February.

Filter No. 5B. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Average Sewage for Filters Nos. 1, 6 and 9A."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	Nitrogen applied.		Per Cent. of Applied Nitrogen.		
		Parts per 100,000.	Units.	Not appearing in Effluent.	In effluent.	
					Oxidized.	Un-oxidized.
1898,*	72.8	4.08	298	40.5	42.9	16.6
1899,	81.7	4.01	327	19.2	58.8	22.0
1900,	109.2	5.06	553	25.5	56.7	17.8
1901,	131.5	5.50	722	27.0	45.0	28.0
1902,	116.9	4.95	579	18.5	58.9	22.6
1903,	90.0	4.84	435	6.3	61.0	32.7
1904,	72.6	6.11	444	22.0	53.8	24.2
Average,	96.4	4.94	476	22.7	54.0	23.7

* Filter started March 5, 1898.

FILTER NO. 6. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Average Sewage for Filter No. 6."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1888,*	39.5	2.70	107	70.4	26.3	3.3
1889, ...	41.0	2.71	111	46.4	52.5	1.1
1890, ...	55.2	2.92	161	55.8	42.1	2.1
1891, ...	61.2	3.32	203	46.0	40.3	5.7
1892, ...	46.9	4.07	191	43.5	40.5	16.0
1893, ...	85.5	3.97	340	29.5	57.7	12.8
1894, ...	54.3	4.53	246	26.6	67.8	5.6
1895, ...	57.6	4.72	272	29.0	55.4	15.6
1896, ...	56.8	5.50	312	36.4	52.0	11.6
1897, ...	60.5	5.02	304	33.7	57.1	9.2
1898, ...	65.6	5.13	336	41.5	53.6	4.9
1899, ...	59.4	3.95	234	26.1	65.3	8.6
1900, ...	51.7	5.02	260	30.6	57.7	11.7
1901, ...	57.6	5.49	316	29.0	43.3	27.7
1902, ...	58.0	4.95	287	15.8	44.6	39.6
1903, ...	70.2	4.84	340	17.9	52.4	29.7
1904, ...	54.4	6.11	333	25.8	49.9	24.3
Average, . . .	57.4	4.41	253	33.7	51.3	15.0

* Filter started Jan. 12, 1888.

FILTER NO. 9A. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Average Sewage for Filter No. 9A."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1890,*	110.0	3.38	372	74.9	2.1	23.0
1891, ...	95.8	3.32	318	45.5	40.3	14.2
1892, ...	68.1	3.77	257	48.8	35.3	15.9
1893, ...	111.7	3.80	424	29.8	51.5	18.7
1894, ...	68.8	4.40	303	22.4	66.0	11.6
1895, ...	66.0	5.02	332	30.1	51.0	18.9
1896, ...	56.3	4.71	265	17.7	68.5	13.8
1897, ...	61.5	5.07	312	19.3	67.7	13.0
1898, ...	74.2	3.48	258	24.1	65.0	10.9
1899, ...	59.5	3.75	223	21.0	64.3	14.7
1900, ...	48.8	5.22	255	28.6	58.6	12.8
1901, ...	53.9	5.60	302	19.3	39.3	41.4
1902, ...	57.0	4.95	282	20.0	46.5	33.5
1903, ...	69.2	4.84	335	20.5	54.1	25.4
1904, ...	53.8	6.11	329	36.4	48.2	15.4
Average, . . .	70.3	4.49	316	29.3	51.3	19.4

* Filter started Nov. 18, 1890.

FILTER NO. 10.— *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Average Sewage for Filter No. 9A."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1894,*	40.0	6.17	247	48.8	45.9	5.3
1895,	36.7	5.02	184	38.8	48.5	12.7
1896,	28.2	4.71	133	27.3	65.1	7.6
1897,	29.5	5.07	149	30.1	60.4	9.5
1898,	28.6	3.48	100	14.1	77.3	8.6
1899,	25.0	3.75	94	19.7	68.3	12.0
1900,	25.5	5.22	133	30.9	62.0	7.1
1901,	27.8	5.60	156	28.5	47.7	23.8
1902,	26.4	4.95	131	30.3	52.5	17.2
1903,	21.7	4.84	105	30.3	56.0	13.7
1904,	17.2	6.11	105	40.6	45.3	14.1
Average,	27.9	4.99	140	32.3	55.7	12.0

* Filter started July 18, 1894.

In connection with this study of nitrogen changes the following table is of interest. It presents the average nitrates in the average yearly effluents of Filters Nos. 1, 2, 4, 6, 9A and 10 inclusive, and shows that the actual amount of nitrates present in these effluents has been a varying quantity, but greater during the past ten years than formerly, and that the nitrates for 1904 have been exceeded in only two years since the beginning of operation of these filters, namely, 1896 and 1900.

Average Nitrates, Filters Nos. 1, 2, 4, 6, 9A and 10.

[Parts per 100,000.]

YEAR.	Nitrates.	YEAR.	Nitrates.
1888,	0.60	1897,	2.89
1889,	1.17	1898,	2.48
1890,	1.11	1899,	2.39
1891,	1.29	1900,	3.06
1892,	1.32	1901,	2.38
1893,	2.03	1902,	2.51
1894,	2.70	1903,	2.83
1895,	2.48	1904,	2.98
1896,	3.00		

Further Nitrogen Studies.

So far, in this nitrogen work, attention has been called only to Filters Nos. 1, 2, 4, 6, 9A and 10, but in tables given beyond are many data in regard to the nitrogen applied to and oxidized by several of the other sand filters that have been operated at the station. Special studies have been made with Filters Nos. 14A, 19 and 100. Each of these filters was operated at rates much greater than those of the filters already discussed, this greater rate being followed since the sewage applied to each filter had been so treated before application that much of the matters in suspension had been removed. All the sewage applied to Filter No. 14A had previously passed through a coke strainer; all the sewage applied to Filter No. 19 after Jan. 20, 1893, had been treated with chemicals to cause precipitation, and all the sewage applied to Filter No. 100 had first passed through a septic tank. The tables show the enormous amount of unoxidized nitrogen calculated as "units" applied to these filters compared with the amount applied to Filters Nos. 1 to 10, inclusive, which received untreated sewage; the average units applied to Filter No. 14A each year being 1,005, to Filter No. 19, 599, and to Filter No. 100, 1,180, compared with averages of 303, 253 and 316, the average amount in units applied to Filters Nos. 1, 6 and 9A, respectively. As a considerable percentage of the matter in suspension in the sewage had been removed, leaving a larger percentage of the total organic matter applied in the form of the more easily oxidized organic matter in solution, the percentage of oxidation in these filters has averaged somewhat greater than in Filters Nos. 1 to 10, inclusive, the highest percentage being given by Filter No. 14A, namely, 70 per cent.

It is evident from a study of all these nitrogen data, together with daily observations of the ease or difficulty of satisfactory operation of various filters after years of work, etc., that there is a fairly well-defined limit to the amount of work that can be accomplished by a sand filter, or, in other words, a filter can care for about so much organic matter, year after year, irrespective, within reasonable limits, of the volume of sewage in which this matter is contained. The greater the percentage of the total organic matter of the sewage in solution, the greater the percentage of oxidation within the filter. Ordinarily, however, only slightly more than 50 per cent. of the applied nitrogen will appear as nitrates in the effluents of filters receiving untreated sewage, and if the remaining nitrogen and carbon are greater than the nitrogen- and carbon-liberating bacteria in the filter can adequately care for, there is an excessive accumulation of organic matter in the filter, eventually necessitating the removal of sand from the filter, prolonged resting, or cropping, which may be the most efficient and practical method. Methods already taken to cause a removal of this nitrogen without removing sand have been described in previous pages.

FILTER NO. 14A. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Strained Sewage."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1894,*	345.1	3.43	1,180	21.6	72.6	5.8
1895,	307.1	4.74	1,452	36.4	55.1	8.5
1896,	279.9	4.29	1,200	27.8	65.0	7.2
1897,	279.7	4.28	1,197	24.5	68.0	7.5
1898,	298.0	2.88	857	12.5	83.0	4.5
Average,	302.0	3.92	1,177	24.6	68.7	6.7

* Filter started Jan. 12, 1894.

FILTER NO. 19. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Regular Sewage" and chemically treated sewage.*]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1890,†	58.2	2.92	170	37.0	57.2	5.8
1891,	90.6	3.32	301	34.4	63.5	2.1
1892,	51.2	3.56	183	38.0	60.0	2.0
1894,	253.2	4.09	1,036	29.4	60.8	9.8
1895,	196.9	5.22	1,028	31.9	60.6	7.5
1896,	189.6	5.43	1,030	33.2	60.7	6.1
1897,	190.0	3.92	745	21.6	70.5	7.9
Average,	147.1	4.07	599	32.2	61.9	5.9
Average 1890 to 1892 inclusive,	66.7	3.27	218	36.7	60.2	3.1
Average 1894 to 1897 inclusive,	207.4	4.67	969	29.0	63.2	7.8

* Regular sewage applied until 1894, after that date sewage clarified by chemicals.
† Filter started Jan. 28, 1890.

FILTER NO. 100. — *Table showing Nitrogen applied and Nitrogen Changes.*

[Sewage applied: "Septic Sewage A."]

	Volume of Sewage applied (Thousand Gallons per Acre Daily).	NITROGEN APPLIED.		PER CENT. OF APPLIED NITROGEN.		
					IN EFFLUENT.	
		Parts per 100,000.	Units.	Not appearing in Effluent.	Oxidized.	Un-oxidized.
1898,*	130.0	4.84	629	20.2	52.1	27.7
1899,	265.4	4.00	1,062	14.3	68.7	17.0
1900,	264.3	5.97	1,578	37.5	52.9	9.6
1901,	254.9	4.90	1,249	17.7	54.9	27.4
1902,	298.4	4.59	1,369	18.5	63.6	17.9
1903,	270.3	3.85	1,041	17.1	70.7	12.2
1904,	222.5	5.75	1,279	44.7	35.7	19.6
Average,	243.7	4.84	1,180	25.7	55.5	18.8

* Filter started Jan. 1, 1898.

Pounds of Nitrogen applied to, stored in, oxidized, etc., in Sand Filters.

Following are several tables of data further to illustrate storage, oxidation, etc., of nitrogen in sand filters. The first of these tables presents figures showing the actual amount of nitrogen, expressed in pounds per acre of filter surface, which has been applied to the various sand filters, stored in these filters, removed by or disappearing from the filters, appearing as nitrates in the effluent of the filters, and appearing as unoxidized nitrogen in the effluents. This table is of interest in showing (1) how small a percentage of the applied nitrogen remains stored in these filters (although this small percentage gives in the course of years an amount of stored nitrogen that is relatively large), and (2) how large a percentage of nitrogen is cared for and changed in other ways than becoming nitrified and passing away as nitrates and nitrites in the effluent of each filter. It will be seen that of the total amount of nitrogen applied to each of the 9 sand filters given in the table, the largest percentage remaining in a filter is in Filter No. 6, namely, 5.9 per cent., and the smallest amount in Filter No. 100, 2.3 per cent., — Filter No. 6 having been operated seventeen years at the time of the examination of sand with the results upon which these figures are based, and Filter No. 100 seven years. The percentage of applied nitrogen appearing as nitrates in the effluents of these filters has varied greatly. With the larger sand filters, namely, Filters Nos. 1, 5A, 6 and 9A, the largest percentage of the applied nitrogen appearing oxidized in any effluent has been in the effluent of Filter No. 1, namely, 53.4 per cent., and the smallest percentage in the effluent of Filter No. 5A, namely, 44.7 per cent. The amount of nitrogen appearing unoxidized in the effluent has also varied greatly, as shown in the table, and the amount which has disappeared, that is, has neither been detected as oxidized or unoxidized nitrogen in the effluents, nor as being stored at the present time in the sand of each filter, has been a large and variable quantity, varying in the case of the large sand filters included in the table from 16.4 per cent. from Filter No. 1 to 46.2 per cent. from Filter No. 5A.

Table showing Nitrogen, in Pounds per Acre, applied to, stored, appearing in Effluent and Lost from Various Sand Filters.

Filter Number.	Date of Sand Analysis.	Days operated.	Pounds of Nitrogen.					
			Applied.	Stored in Sand.	In Effluent.	Lost.*	In effluent.	
							Oxidized.	Un-oxidized.
1, . . .	Oct. 10, 1904,	5,264	132,384	5,036	105,730	21,618	70,778	34,952
5A, . .	Mar. 1, 1898,	3,187	94,427	3,081	47,610	43,736	42,056	15,554
6, . . .	Oct. 10, 1904,	5,262	110,060	6,447	73,366	30,247	56,771	16,585
9A, . .	Oct. 10, 1904,	4,369	114,228	5,406	81,222	27,600	59,104	22,118
13A, . .	Mar. 7, 1897,	1,393	81,382	4,165	58,147	19,070	56,875	1,272
19, . . .	Mar. 7, 1897,	2,169	107,820	6,751	73,260	27,809	41,335	31,925
100, . . .	Feb. 1, 1905,	2,217	216,412	4,956	152,396	59,060	119,341	33,055
116, . . .	Mar. 25, 1901,	780	71,888	2,456	46,325	23,107	41,084	5,241
118, . . .	Mar. 25, 1901,	735	77,531	3,666	50,020	23,845	42,456	7,564

* Not corrected for nitrogen in original sand or for nitrogen in sand removed by scraping.

Corrections which may be applied to tables of nitrogen in sand: —

Nitrogen removed by Scraping; All Previous to the End of 1893.

Filter No. 1,	3,558 pounds per acre.
Filter No. 6,	1,203 pounds per acre.
Filter No. 9A,	591 pounds per acre.

Table showing Per Cent. of Applied Nitrogen, stored in Sand Filters.

Filter No. 1,	3.8	Filter No. 19,	6.3
5A,	3.3	100,	2.3
6,	5.9	116,	3.4
9A,	2.3	118,	4.7
13A,	5.1		

Table showing Pounds of Nitrogen per Acre at Different Depths in Sand of Sewage Filters Nos. 1, 5A, 6, 9A, 13A, 19, 100, 116, 118.

FILTER NUMBER.	Date of Sand Analysis.	Days operated.	POUNDS OF NITROGEN IN SAND.					
			First Foot.	Second Foot.	Third Foot.	Fourth Foot.	Fifth Foot.	Total.
1, . . .	Oct. 10, 1904,	5,264	3,224	778	440	354	240	5,036
5A, . . .	Mar. 1, 1898,	3,187	1,475	444	438	275	449	3,081
6, . . .	Oct. 10, 1904,	5,262	4,289	1,301	521	336	-	6,447
9A, . . .	Oct. 10, 1904,	4,369	3,526	927	388	304	261	5,406
13A,* . . .	Mar. 7, 1897,	1,393	3,220	396	257	199	93†	4,165
19,‡ . . .	Mar. 7, 1897,	2,169	5,651	611	206	148	135	6,751
100,§ . . .	Feb. 1, 1905,	2,217	2,861	701	760	623‖	-	4,956
116,§ . . .	Mar. 25, 1901,	780	1,708	255	178	172	143‖	2,456
118,§ . . .	Mar. 25, 1901,	735	2,857	327	194	146	142	3,666

* Settled sewage applied. † Six inches.
‡ 1890–93, regular sewage applied; 1894–97, chemical precipitated sewage applied.
§ Septic sewage applied. ‖ Nine inches.

Table showing Average Nitrogen Conversion, etc., of Filters operated with Untreated Sewage.

FILTER NUMBER.	Period operated.	Volume of Sewage applied (Thousand Gallons per Acre per Day).	Nitrogen applied (Parts per 100,000).	PER CENT. OF APPLIED NITROGEN.			
				IN EFFLUENT.		Lost.*	Oxidized+Lost.
				Oxidized.	Un-oxidized.		
1, ...	1888–1904,	71.3	4.25	53.4	18.1	28.5	81.9
2, ...	1888–1904,	37.0	4.25	52.6	12.2	35.2	87.8
4, ...	1888–1904,	23.6	4.31	47.8	5.8	46.4	94.2
5A, . . .	1891–1898,	79.3	4.50	44.7	19.8	35.5	80.2
6, ...	1888–1904,	57.4	4.41	51.3	15.0	33.7	85.0
9A, . . .	1890-1904,	70.3	4.49	51.3	19.4	29.3	80.6
10, ...	1894–1904,	56.5	4.99	55.7	12.0	32.3	88.0
19, ...	1890–1892,	66.7	3.27	60.2	3.1	36.7	96.9
29, ...	1890–1892,	25.7	3.31	63.8	6.6	29.6	93.4
30, ...	1890–1894,	55.1	3.34	76.6	4.8	18.6	95.2
15B, . . .	1892–1897,	374.0	4.25	34.1	18.8	47.1	81.2
16B, . . .	1892–1897,	367.4	4.25	29.8	23.8	46.4	76.2
5B, . . .	1898–1904,	96.4	4.94	48.2	23.7	28.1	76.3
80, ...	1897–1898,	90.7	4.10	33.0	8.5	58.5	91.5
95, ...	1897–1900,	96.6	4.29	63.6	2.8	33.6	97.2

* Nitrogen applied which did not appear in the effluent, including nitrogen in the sand and nitrogen set free.

Table showing Average Nitrogen Conversion, etc., of Filters operated with Treated Sewage.

Operated with Settled Sewage.

Filter Number.	Period operated.	Volume of Sewage applied (Thousand Gallons per Acre per Day).	Nitrogen applied (Parts per 100,000).	Per Cent. of Applied Nitrogen.			
				In Effluent.		Lost.*	Oxidized + Lost.
				Oxidized.	Un-oxidized.		
13A, ...	1894-1897	162.1	4.34	65.6	6.0	28.4	94.0
Operated with Strained Sewage.							
14A, ...	1894-1899	276.0	3.64	70.2	7.2	22.6	92.8
Operated with Precipitated Sewage.							
19, ...	1894-1897	207.4	4.67	63.2	7.8	29.0	92.2
Operated with Andover Septic Sewage.							
A. E. S. F.,† . .	1899-1902	118.0	7.22	25.8	45.2	29.0	54.8
Operated with Septic Sewage.							
100, ...	1898-1904	243.7	4.84	55.5	18.8	25.7	81.2
116, ...	1899-1900	208.8	5.32	56.9	7.3	35.8	92.7
118, ...	1899-1900	254.8	4.99	54.9	9.6	35.5	90.4
Operated with Effluent from Filters Nos. 15B and 16B.							
12A, ...	1892-1897	570.7	0.90‡ 2.26§	23.6‡	7.3‡	3.5§	27.1

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* Nitrogen applied which did not appear in the effluent, including nitrogen in the sand and nitrogen set free as gases.

† A. E. S. F., Andover Experimental Sand Filter. ‡ Unoxidized. § Total.

Table showing Average Nitrogen Conversion, etc., of Filters operated with Treated Sewage — Concluded.

Operated with Effluent from Filters Nos. 135 and 136.

Filter Number.	Period operated.	Quantity applied (Thousand Gallons per Acre per Day).	Nitrogen applied (Parts per 100,000).	Per Cent. of Applied Nitrogen.			
				In effluent.		Lost.*	Oxidized+ Lost.
				Oxidized.	Un-oxidized.		
185, . . .	1902–1903	834.2	1.80† 3.96‡	37.2†	44.4†	9.2‡	46.4

Operated with Settled Effluent from Filters Nos. 135 and 136.

217, . . .	1903	1,937.0	1.58† 3.98‡	15.8†	67.7†	6.7‡	22.5
224, . . .	1904	496.1	1.94† 4.26‡	17.5†	12.4†	32.0‡	49.5

* Nitrogen applied which did not appear in the effluent, including nitrogen in the sand and nitrogen set free as gases. † Unoxidized. ‡ Total.

Conversion of Nitrogen by Municipal Sewage Filtration Areas.

At the beginning of this discussion of nitrogen disposal, on page 210, the statement was made that with the Lawrence filters receiving strong but stale sewage a greater percentage of nitrogen is nitrified in the filter than in the municipal areas of the State, from the surface of many of which much organic matter is from time to time removed. The truth of this statement is shown by a following table, giving the percentage of the applied nitrogen that is oxidized and appears as nitrates in the effluents of these areas, the figures of these tables being obtained from the data given in a report upon "The Examination of Sewer Outlets and the Effect of Sewage Disposal" in the report of the Board for 1903, page 305. It will be noticed from the following tables that this percentage is very much lower than is the case with the Lawrence filters, only one area showing over 50 per cent. of the applied nitrogen appearing nitrified in its effluent, and few showing even 30 per cent. of the applied nitrogen nitrified, the average amount of nitrogen that appears as nitrates being only 24.9 per cent. of the total nitrogen applied. The average amount of the total nitrogen that is unaccounted for, that is, that does not appear in the effluents of these areas, is noticeably larger than with the Lawrence filters, showing plainly the removal of much matter from the surfaces of these areas, the average amount removed in this way, stored, and disappearing by nitrogen liberation being 61.3 per cent. of the nitrogen applied, judging by the analyses of sewages and effluents covering a series of years, as given in the table.

In this calculation of the amount of nitrogen oxidized at these municipal areas and the amount appearing unoxidized in their effluents, a certain amount of error enters that does not enter in the calculation of these factors in connection with the Lawrence filters. That is to say, at the areas a certain amount of ground water is mixed with the true sewage effluent. The amount of ground water present in most of these effluents, however, is not great enough to decrease materially the figures of oxidized nitrogen given on the table or to increase the figures showing unoxidized nitrogen.

Table showing Conversion of Nitrogen by Municipal Sewage Filters in Massachusetts.

AREA.	Years included in Results on Table.	PARTS PER 100,000.			PER CENT. OF APPLIED NITROGEN.		
		Average Applied Nitrogen.	NITROGEN IN EFFLUENT.		In Effluent unoxidized.	In Effluent oxidized.	Unaccounted for (not appearing in Effluent).
			Unoxidized.	Oxidized.			
Andover, . . .	1900–1903	7.02	0.96	1.07	13.7	15.2	71.1
Brockton, . .	1897–1903	4.73	0.14	2.18	3.0	41.0	56.0
Clinton:							
East underdrain,	1900–1903	5.66	1.01	0.70	17.8	12.4	69.8
West underdrain,	1900–1903	5.66	0.68	0.92	12.0	16.2	71.8
Concord, . . .	1901–1903	1.20	0.02	0.74	1.7	61.7	36.6
Framingham:							
East underdrain,	1893–1903	5.10	0.27	1.16	5.3	22.7	72.0
West underdrain,	1893–1903	5.10	0.18	1.01	3.5	19.8	76.7
Gardner, . . .	1892–1903	3.21	0.80	0.54	25.7	17.4	56.9
Hopedale, . .	1901–1903	2.75	0.85	1.14	30.9	41.5	27.6
Leicester, . .	1897–1903	3.78	0.93	0.93	24.6	24.6	50.8
Marlborough, . .	1892–1903	4.28	0.67	0.85	15.6	19.9	64.5
Natick, . . .	1897–1903	1.71	0.27	0.50	15.8	29.2	55.0
Pittsfield, . .	1903	3.23	0.28	0.69	8.7	21.4	69.9
Southbridge, . .	1900–1903	2.14	0.22	0.16	10.3	7.5	82.2
Spencer, . . .	1898–1903	2.32	0.22	0.71	9.5	30.6	59.9
Stockbridge, . .	1900–1903	1.48	0.19	0.23	12.8	15.5	71.7
Westborough, . .	1900–1903	2.67	0.60	0.75	22.4	28.1	49.5

TOTAL ORGANIC MATTER IN SAND FILTERS NOS. 1, 6 AND 9A, AS SHOWN BY DETERMINATIONS OF COMBUSTIBLE MATTER OR LOSS ON IGNITION OF THE SAND FROM THESE FILTERS.

When Filters Nos. 1, 6 and 9A, $\frac{1}{200}$ of an acre in area, were first put into operation, a determination was made of the total organic matter on the sand grains; that is, the per cent. in weight lost when portions of the sand used were heated to a red heat for a given period. At the end of 1904, determinations were again made with samples collected from different depths in each filter, and the results are given in a following table. These determinations show — calculating as organic matter all matter consumed when sand is heated to a red heat — that at the beginning of operation in 1888 Filter No. 1 had upon its sand grains .42 per cent. of organic matter, or in the entire filter 468 pounds of organic matter, the total weight of sand in this filter being 111,330 pounds. At the end of 1904, after seventeen years of operation, the increase of organic matter was 823 pounds, making the total amount present 1,291 pounds. Four hundred and fifty pounds, or more than 50 per cent., of this increase was in the upper foot of the filtering material. In Filter No. 6 the increase was from 529 to 1,092 pounds; 563 pounds, or about 75 per cent., of the total increase was in the upper foot of the filtering material. With Filter No. 9A the increase has been from 969 to 1,759 pounds, or 81 per cent.; and 71 per cent. of this total increase of organic matter is stored in the upper foot of filtering material. These determinations are of value, supplement the determinations and calculations of the actual amount of nitrogenous matter present given in a previous portion of this report, and show clearly that the stored *nitrogenous* matter is but a small percentage of the entire stable organic matter that has accumulated in these filters, resistant to such bacterial actions as result in the rapid production of nitrates, passage of nitrogen into the air, etc. They also aid in a clear understanding of the greater compactness of the upper portion of the filter due to stored organic matter. Tables showing the results follow.*

Total Nitrogen and Total Organic Matter stored in Filters Nos. 1, 2 and 9A.

	Stored Nitrogen (Pounds).	Total Organic Matter (Pounds).
Filter No. 1, ...	25	1,291
Filter No. 2, ...	32	1,029
Filter No. 9A, ...	27	1,759

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* The figures of total organic matter presented in these tables are undoubtedly somewhat large, owing to the method of determination. More accurate methods are being used during 1905.

Total Organic Matter stored in Filter No. 1 at Different Depths, as shown by Determinations of Loss on Ignition.

DEPTH IN INCHES.	Loss on Ignition (Per Cent. by Weight).	Corrected Loss.	Pounds of Sand between Depth.	Pounds Loss at Given Depth.	Pounds Loss per Acre at Given Depth.
0–6, ...	2.53	2.11	11,123	234.7	46,940
6–9, ...	2.51	2.09	5,561	116.1	23,220
9–12, ...	2.20	1.78	5,561	99.0	19,800
12–15, ...	1.05	0.62	5,561	34.5	6,900
15–18, ...	0.91	0.49	5,561	27.3	5,460
18–24, ...	0.90	0.48	11,123	59.9	11,980
24–36, ...	0.86	0.44	22,246	97.9	19,580
36–48, ...	0.82	0.40	22,246	89.0	17,800
48–60, ...	0.71	0.29	22,246	64.2	12,840
Total pounds, . . .	–	–	–	822.6	164,520

Total Organic Matter stored in Filter No. 6 at Different Depths, as shown by Determinations of Loss on Ignition.

DEPTH IN INCHES.	Loss on Ignition (Per Cent. by Weight).	Corrected Loss.	Pounds of Sand between Depth.	Pounds Loss at Given Depth.	Pounds Loss per Acre at Given Depth.
0–6, ...	4.01	3.14	12,142	381.2	76,240
6–9, ...	2.82	1.95	6,071	118.4	23,680
9–12, ...	2.07	1.20	6,071	72.8	14,560
12–15, ...	1.97	1.10	6,071	66.8	13,360
15–18, ...	1.43	0.56	6,071	40.0	8,000
18–24, ...	1.33	0.46	12,142	55.9	11,180
24–36, ...	1.08	0.22	24,284	54.7	10,940
36–48, ...	0.85	–	–	–	–
Total pounds, . . .	–	–	–	789.8	157,960

Total Organic Matter stored in Filter No. 9A at Different Depths, as shown by Determinations of Loss on Ignition.

Depth in Inches.	Loss on Ignition (Per Cent. by Weight).	Corrected Loss.	Pounds of Sand between Depth.	Pounds Loss at Given Depth.	Pounds Loss per Acre at Given Depth.
0–6, ...	2.62	2.12	10,585	230.2	46,040
6–9, ...	2.53	2.03	5,292	107.2	21,440
9–12, ...	2.08	1.58	5,292	83.6	16,720
12–15, ...	1.39	0.80	5,292	42.4	8,480
15–18, ...	0.94	0.44	5,292	23.3	4,660
18–24, ...	0.64	0.14	10,585	15.2	3,040
24–36, ...	0.62	0.12	21,170	25.4	5,080
36–48, ...	0.59	0.09	21,170	19.1	3,820
48–60, ...	0.58	0.08	21,170	16.9	3,380
Total pounds, . . .	-	-	-	563.3	112,660

Acidity or Alkalinity of the Effluents of Sewage Filters as an Index of Good or Poor Purification.

During the investigation in regard to the removal of organic matter from sand filters discussed in previous pages, determinations were begun in order to learn the degree of alkalinity of the effluents of filters of various kinds. In the determination of this alkalinity various indicators have been used, but methyl-orange and gallein are the only two which have been found of practical value. Neither is affected by carbon dioxide; and methyl-orange does not indicate organic acids, while gallein does. The results obtained by the two indicators were practically the same, however, indicating the absence of organic acids from the effluents tested. The determinations made upon the effluents of the small Filters Nos. 265, 266, 267, 268 and 269 (see pages 207–209), and also upon the effluents of the large sand filters in operation at the station, show clearly that when the most complete purification and the highest nitrification are occurring in these filters, their effluents are either acid or only slightly alkaline, and that the poorer the nitrification, the greater is the degree of alkalinity of the effluents. As shown in a following table, the effluents of Filters Nos. 1, 4, 5, 6, 9A and 10 were all slightly acid when examined in September, when nitrification was high; while in December, when nitrification was lower, the effluents of nearly all these filters were slightly alkaline. The different character of the effluents of contact and intermittent-continuous filters in this respect is also clearly shown by the table. Notwithstanding high nitrification in intermittent-continuous Filters Nos. 135 and 136, enough free ammonia, etc., is always present in their effluents to cause high alkalinity, and this characteristic is even more pronounced in the effluents of contact filters giving low nitrification. The higher the free ammonia and the lower the nitrates, the greater the alkalinity, is the general rule. Filters of fresh sand not yet exhausted of its carbonates, or constructed of sand containing a greater percentage of carbonates than Lawrence sands, may produce effluents which do not follow this rule.

Table showing Results of Determinations of Alkalinity of Sewage and Effluents.

Samples from—	September.		October.		November.		December.	
	Methyl-orange.	Gallein.	Methyl-orange.	Gallein.	Methyl-orange.	Gallein.	Methyl-orange.	Gallein.
Regular sewage,	-	-	-	-	26.0	26.0	28.4	28.4
Filter No. 1, .	—1.3	—0.5	—2.0	-	—2.0	—2.0	1.0	1.0
2, .	1.2	1.2	1.0	0.8	0.5	-	0.1	0.1
4, .	—0.4	—0.3	0.0	0.0	0.2	-	—0.1	—0.1
5, .	—3.6	—1.5	—1.7	—0.9	—1.1	—1.1	3.1	3.1
6, .	—0.6	—0.5	—0.6	-	0.5	-	—1.3	—1.3
9A, .	—1.6	—1.0	—1.5	—1.0	—2.2	—2.1	1.3	1.3
10, .	—0.2	—0.2	0.0	0.0	—0.5	—0.5	—0.8	—0.8
100, .	0.4	0.4	0.2	0.2	0.2	0.2	4.8	4.8
135, .	1.2	1.2	8.4	8.2	2.4	2.3	6.0	6.0
136, .	3.2	3.2	16.4	16.4	5.6	5.6	12.4	12.4
175, .	10.6	10.8	10.0	10.0	10.4	10.4	2.0	2.0
176, .	17.8	17.6	13.6	13.6	16.4	16.2	5.6	5.6
221, .	6.6	6.6	15.6	15.2	21.0	21.0	16.0	16.0
222, .	7.4	7.6	6.8	6.8	12.2	11.8	16.4	16.4
224, .	1.2	1.3	4.2	4.2	2.3	2.3	1.0	1.0
232, .	-	-	690.0	650.0	650.0	640.0	360.0	360.0
233, .	2.4	2.5	12.0	12.0	14.4	14.4	13.0	13.0
234, .	8.2	8.0	21.2	21.2	34.0	-	18.0	18.0
235, .	0.0	0.0	3.6	3.6	4.6	4.2	3.6	3.6
236, .	7.0	7.2	29.2	29.2	23.0	23.0	20.0	20.0
237, .	4.8	4.8	12.0	12.2	11.6	11.6	12.4	12.4
238, .	13.2	13.2	27.6	27.6	-	-	-	-
241, .	45.6	36.0	-	-	36.0	34.0	-	-
242, .	1.8	1.8	1.6	-	1.0	1.0	-	-
247, .	15.6	16.0	17.6	17.6	19.0	19.0	15.2	15.2
248, .	7.2	7.2	31.2	31.2	30.0	30.0	19.2	19.2
249, .	2.4	2.4	5.0	5.0	2.9	3.0	1.2	1.2
250, .	2.2	2.2	5.5	5.5	2.2	2.2	0.5	0.5

Experiments to identify the Acid in Acid Sewage Effluents.

Examinations were made of effluents which were found to be acid, and this acid was shown to be a mixture of nitric and hydrochloric acid. An example of this follows.

One hundred cubic centimeters of the effluent of Filter No. 5B, having a reaction of —4.5, were evaporated. As the acidity of the residue was 0, acid equivalent to 4.5 parts calcium carbonate was driven off, and there was also a loss, during the evaporation, of .67 part of nitrogen as nitric acid. This .67 part of nitrogen was equivalent to 2.4 parts of calcium carbonate, hence the acid equivalent to the remaining 2.1 parts of calcium carbonate must have been due to some other acid. To determine this other acid, 100 cubic centimeters of the effluent of Filter No. 5B were distilled under reduced pressure, and a portion of the effluent of Filter No. 9A, having a reaction of —1.6, was treated in the same way, with the following results: —

Effluent of Filter No. 5B.

	Parts.		Parts.
Acidity of sample,	—4.5	Nitrogen as nitrate in distillate,	0.572
Acidity of residue,	0.0	Chlorine in distillate,	1.88
Acidity of distillate,	—4.4		

0.572 parts nitrogen = 2.1 parts calcium carbonate.
1.88 parts chlorine = 2.6 parts calcium carbonate.
4.7

Effluent of Filter No. 9A.

	Parts.		Parts.
Acidity of sample,	—1.6	Nitrogen as nitrate in distillate,	0.227
Acidity of residue,	0.0	Chlorine in distillate,	0.25
Acidity of distillate,	—1.6		

0.227 parts nitrogen = 0.82 parts calcium carbonate.
0.25 parts chlorine = 0.35 parts calcium carbonate.
1.20

The nitrogen as nitrate and chlorine as hydrochloric acid in the distillate account within the limits of error for the acidity of the distillate and the original sample.

Similar results were obtained from a solution containing free HNO_3 and sodium chloride in the same amounts as in these effluents.

These results show that the acidity is due to free nitric and hydrochloric acids, and the hydrochloric acid is probably liberated from the sodium chloride by free nitric acid. Theoretically, if diluted nitric acid is added to a dilute solution of sodium chloride, the sodium chloride gives up part of its base to the nitric acid, so that there will be equivalent amounts of each acid free in the solution.

Total Organic Nitrogen (Kjeldahl Determinations).

During the year a large number of Kjeldahl determinations of the organic nitrogen in sewage and the effluents of sewage filters have been made. It has long been recognized that albuminoid ammonia determinations, while of great value in sewage analysis, give a percentage of the total organic nitrogen present that varies with the age and quality of the sample of sewage examined. For this reason, Kjeldahl determinations are of greater value and significance. The monthly averages of practically all the Kjeldahl results are given in the regular tables of analyses of sewages and effluents in various portions of this report. They add very materially to these tables, and show more clearly than the albuminoid ammonia determinations the actual amount of nitrogen present in the sewage used at the station. There is presented here a table summarizing the Kjeldahl results, and showing the percentage that the organic nitrogen, determined as albuminoid ammonia, is of the actual organic nitrogen. Studying this table, it will be seen that practically 45 per cent. of the organic nitrogen in the effluents of all classes of sewage filters in operation at the station is obtained by the albuminoid ammonia method. In the samples of unfiltered sewage collected at the station after this sewage has passed through a 2½-inch pipe, 4,400 feet long, reaching from the sewer to the station, 39 per cent. of the nitrogen is found by the albuminoid ammonia method; and 38 per cent. of the nitrogen in the stale sewage reaching the Andover filtration area is also found by this method. Fresh sewage flowing in the Lawrence Street sewer yields only 28.5 per cent. of its organic nitrogen by the albuminoid ammonia determination.

Kjeldahl determinations of the nitrogen in sewage after this sewage has been filtered through filter paper show that a greater percentage of the nitrogen in solution than of the total nitrogen is detected by the albuminoid ammonia determination. This result is in line with previous work, and indicates that the organic matter in solution is the most easily oxidized, and hence the first to putrefy.

Average of Kjeldahl Ratios. [Figures represent Percentage that Nitrogen determined as Albuminoid Ammonia is of Total Nitrogen.]

1904.	Average Effluents of Filters.			Regular Sewage.		Average Sewage.	Andover Sewage (Settled).		Effluent of Filter No. 222 (Andover).	Lawrence Street Sewage.	
	Contact.	Trickling.	Sand.	Unfiltered.	Filtered.	Unfiltered.	Unfiltered.	Filtered.	Unfiltered.	Unfiltered.	Filtered.
January, . .	–	–	–	–	–	–	38.0	41.9	–	21.0	25.3
February, . .	–	–	–	–	–	40.2	34.0	33.8	–	22.6	15.5
March, . . .	–	–	–	–	–	34.4	25.1	24.1	–	31.8	34.7
April, . . .	–	–	–	–	–	32.3	28.1	28.2	–	35.4	41.7
May, . . .	–	–	–	–	–	41.7	32.5	26.5	–	33.6	27.2
June, . . .	–	–	–	–	–	46.8	46.0	49.2	–	28.2	25.7
July, . . .	–	–	–	43.1	48.5	42.5	47.3	53.4	–	23.8	37.1
August, . .	46.6	47.4	–	44.3	47.8	40.6	43.7	46.8	–	32.7	32.2
September, . .	47.3	46.5	–	49.7	54.0	44.5	46.6	55.8	44.5	31.0	27.5
October, . .	47.1	43.1	42.3	40.5	42.4	37.7	36.1	48.6	46.4	24.2	25.1
November, . .	44.5	43.6	48.3	35.6	39.6	32.6	36.7	41.5	47.5	29.5	23.4
December, . .	38.9	42.0	44.4	25.6	25.3	30.1	40.5	39.8	39.5	28.8	24.7
Average, .	44.9	44.5	45.0	39.8	44.4	38.5	37.9	40.8	44.5	28.5	28.3

BACTERIOLOGY AND BIOCHEMISTRY OF SEWAGE PURIFICATION.

Much attention has been given during the past ten years to the study of the bacteria in sewage and in the effluents from various types of sewage filters. The data concerning the numbers of bacteria in samples from these sources have been published annually, as a portion of the routine analytical work, to show the degree of bacterial purification accomplished by the various filters, septic tanks, etc. Much information has also been acquired as to kinds of bacteria, as to the removal of bacteria of certain types, and as to the biochemical reactions occurring in filters and the types of bacteria causing the reactions. A summary of these data is here given.

During the years 1896–99, the special bacteriological investigations were devoted to the determination of the kinds of bacteria in sewage before and after treatment by different methods, especially the bacteria in septic sewage and in the effluents from filters operated with septic sewage. Twenty species of bacteria were found to be of common occurrence in samples of this class, and the per cent. which each species formed of the total number of bacteria in the samples examined, and the per cent. of the samples examined which contained each species, are shown in Table No. 1, together with the average number of bacteria per cubic centimeter, the per cent. of the total number of bacteria which liquefied gelatin in four days, and the per cent. of the total number of bacteria which would grow at body temperature.

In this table a number of the species are designated by names. As this work was one of comparative and quantitative species determination, rather than a detailed study of the species themselves, it is of minor importance that the true identity of the species be established. While the species were completely studied as far as was possible by the methods in vogue at that time, many of the data at present considered necessary for identifying bacterial species were not obtained, and the names given should be considered as indicating only approximately the class or group of organisms in which the species would be included. The determination of the per cent. of the total bacteria which will grow at body temperature has a special significance, in that disease germs grow best at that temperature, and the bacteria which fail to develop under these conditions could not be of pathological importance. It will be noted that not only do the septic tank and the two filters studied remove a large percentage of the total bacteria, but also that the removal of the bacteria which are able to grow at body temperature is much greater than that of the other kinds.

TABLE No. 1.—*Showing Species of Bacteria in Sewage, Septic Sewage and in the Effluents of Filters receiving Septic Sewage.*

	SEWAGE.		SEPTIC SEWAGE.		EFFLUENT OF FILTER No. 100.		EFFLUENT OF FILTER No. 103.	
	AVERAGE NUMBER OF BACTERIA PER CUBIC CENTIMETER.							
	1,446,000.		**528,000.**		**56,500.**		**26,900.**	
	Per Cent. of Samples Present in —	Per Cent. of Total Bacteria.	Per Cent. of Samples present in —.	Per Cent. of Total Bacteria.	Per Cent. of Samples present in —	Per Cent. of Total Bacteria.	Per Cent. of Samples present in —	Per Cent. of Total Bacteria.
Liquefy gelatin, . .	–	16.0	–	9.5	–	6.8	–	11.1
Grow at body temperature,	–	33.6	–	26.1	–	36.9	–	28.0
B. coli, ...	–	2.0	–	8.1	–	18.3	–	22.2
B. subtilis, ...	100.0	4.2	84.0	1.6	100.0	3.4	100.0	5.0
B. vulgaris, . . .	0.0	0.0	6.0	0.2	13.0	0.2	5.0	0.1
B. megatherium, . .	8.0	0.2	5.0	0.3	7.0	0.1	7.0	0.1
B. prodigeosus, . . .	0.0	0.0	16.0	0.1	0.0	0.0	0.0	0.0
B. hyalinus, . . .	85.0	4.1	86.0	2.0	60.0	1.3	45.0	0.8
B. flavescens, . . .	13.0	0.4	11.0	0.8	3.0	0.1	3.0	0.2
B. stoloniferus, . . .	23.0	0.6	10.0	0.7	0.0	0.0	3.0	0.2
B. aerogenes, . . .	53.0	2.1	46.0	1.4	43.0	0.4	28.0	1.1
Ps. putida, ...	100.0	16.0	79.0	12.6	100.0	17.0	100.0	15.6
Ps. ochracea, . . .	68.0	5.4	62.0	1.5	56.0	0.3	62.0	1.1
Str. proteus, . . .	13.0	0.4	28.0	0.9	23.0	0.3	25.0	2.6
Sp. No. 059, . . .	–	1.6	–	5.8	–	2.5	–	3.1
Sp. No. 062, . . .	0.0	0.0	14.0	0.7	0.0	0.0	0.0	0.0
Sp. No. 063, . . .	0.0	0.0	14.0	7.6	0.0	0.0	0.0	0.0
Sp. No. 077, . . .	87.0	2.1	69.0	1.5	67.0	0.9	77.0	1.2
Sp. No. 078, . . .	0.0	0.0	4.0	0.1	0.0	0.0	0.0	0.0
Sp. No. 079, . . .	17.0	0.9	11.0	2.8	3.0	0.2	3.0	0.1
Sp. No. 082, . . .	0.0	0.0	1.0	0.1	0.0	0.0	3.0	0.4
Sp. No. 090, . . .	62.0	4.3	47.0	3.5	30.0	1.0	25.0	0.6

During October and November, 1901, studies were made of a few of the sewages applied to and effluents of sewage filters of coarse materials, the investigations at this time being devoted to a determination of the ratio of liquefying bacteria, spores and B. coli to the total number of bacteria. The significance of the B. coli determinations is too well known to require discussion, the removal of this type indicating the removal of other non-spore-bearing disease germs. The studies of the presence of spore-bearing types were undertaken to determine roughly what would be the fate of spore-bearing disease germs, such as the bacillus of anthrax. The results of these studies show clearly that, while there is a material reduction in the total number of bacteria and in the number of bacteria of non-spore-bearing types by passage through the septic tank and through contact and continuous-intermittent or trickling filters, there is no perceptible reduction in the numbers of spore-bearing bacteria.

TABLE NO. 2. — *Showing the Passage of Spore-bearing Bacteria and B. Coli through Septic Tanks and Sewage Filters.*

SAMPLES FROM —	BACTERIA.			SPORES.			B. COLI.
	Average Number per Cubic Centimeter.	Per Cent. which Liquefied Gelatin.	Average Number of Types which Liquefy Gelatin.	Average Number per Cubic Centimeter.	Per Cent. of Total Bacteria.	Average Number of Types per Sample.	Per Cent. of Total Bacteria.
Sewage, . .	2,427,000	7.7	4	61	0.0029	5	4.00
Septic sewage, .	1,382,000	6.8	4	59	0.0052	6	0.86
Filter No. 100, .	99,400	10.6	2	40	0.0520	2	0.11
Filter No. 103, .	121,600	11.1	1	38	0.0970	2	0.30
Filter No. 137, .	688,000	7.6	2	38	0.0070	2	0.20
Filter No. 135, .	3,000	33.0	2	142	4.7000	1	–
Filter No. 136, .	7,000	29.0	3	43	0.6100	3	–

During 1902-1904, inclusive, extensive studies were made of the passage of B. coli through sewage filters. While B. coli, as has been pointed out many times in previous reports, cannot be considered to be a disease germ, nevertheless, as regards length of life under a variety of unfavorable conditions, it is very similar to the bacillus of typhoid fever, and from its study in sewage effluents we may draw inferences as to what would be the effectiveness of these filters in removing that organism. From the results obtained it is evident that sewage filters of coarse materials, operating at high rates, will not remove all the bacteria of the colon type. On the other hand, intermittent sand filters may remove all, or at least a large proportion of these germs at certain times. The large Filters Nos. 2 and 4, filled with fine sand and operated at low rates, have been particularly efficient in this respect, B. coli being always absent from 1 cubic centimeter samples of the effluents from these filters, and were only occasionally found when 100 cubic centimeters of the water were examined. The percentage removal of B. coli during treatment by different methods has been as follows: —

Septic Tank A removed an average of 46 per cent. of the B. coli, the removal varying from 71 per cent. in March, 1904, to none in April of the same year.

Of the sand filters receiving raw sewage, Filters Nos. 2 and 4 removed practically all of the B. coli; Filters Nos. 6 and 10 removed over 99 per cent.; Filter No. 9A removed over 98 per cent.; and Filters Nos. 1 and 5 removed about 97 per cent. of the B. coli.

Filter No. 100, a sand filter, removed over 98 per cent. of the B. coli from the septic sewage with which it was operated.

Of the contact filters operating with raw sewage, Filter No. 221 removed nearly 49 per cent., and Filter No. 176 removed over 71 per cent.; while Filter No. 103, which received septic sewage, removed over 76 per cent. of the B. coli applied. Filter No. 175, which received strained sewage, removed only a very small percentage of the B. coli.

Both of the intermittent-continuous or trickling filters, constructed of coarse materials, and operated with raw sewage at high rates, showed a high percentage removal of the test organism, Filter No. 135 removing over 99 per cent., and Filter No. 136 about 97 per cent. In the two tables following are shown the results of this investigation, Table No. 3 showing the average monthly number of B. coli in the samples from the different sources, and Table No. 4 showing the percentage removal of the test germ by different methods of treatment.

TABLE NO. 3. — *Showing Average Monthly Number of B. Coli per Cubic Centimeter in Sewage and the Effluents from Sewage Filters.*

SAMPLES FROM —	Jan., **1902.**	Feb., **1902.**	July, **1902.**	Dec., **1903.**	Jan., **1904.**	Feb., **1904.**	March, **1904.**	April, **1904.**	May, **1904.**	June, **1904.**
Lawrence Street sewage, .	–	–	–	43,300	48,700	116,900	73,500	67,500	231,000	111,000
Station sewage, . . .	–	–	–	110,000	97,600	76,500	57,200	41,500	144,000	87,800
Septic sewage, A, . .	–	–	–	40,000	52,800	32,800	16,500	53,800	86,400	47,100
Effluent of Filter No. 1, .	12,000	4,700	450	7,300	450	2,300	7,700	1,900	65	200
" " 2, .	0*	0*	0*	0*	0*	0*	0*	0†	0†	0*
" " 4, .	0†	0†	0†	0*	0*	0*	0*	0*	0*	0*
" " 5, .	8,500	1,100	2,500	2,200	6,700	5,100	3,900	400	275	95
" " 6, .	–	–	1,040	0*	250	1,400	600	1,600	21	500
" " 9A, .	0	0	0	2,000	5,900	425	400	150	3	95
" " 10, .	550	600	24	1	30	140	300	24	5	0*
" " 100, .	–	–	–	1,100	170	600	140	1,800	650	1,000
" " 103, .	13,500	16,300	65	17,300	10,300	11,800	1,700	10,000	15,300	–
" " 135, .	295	0	1,600	190	300	2,400	350	140	1,400	–
" " 136, .	550	400	6,800	1,800	1,900	4,000	1,900	900	5,500	–
" " 175, .	13,700	3,600	–	22,800	40,000	35,300	15,000	19,000	33,000	44,000
" " 176, .	11,500	7,200	–	29,300	35,000	16,300	6,800	36,000	42,400	8,500
" " 221, .	–	–	–	25,000	33,200	27,500	16,500	22,500	90,000	99,400

* B. coli absent from both 1 and 100 cubic centimeters.

† B. coli absent from 1 cubic centimeter, but found occasionally in 100 cubic centimeters.

TABLE NO. 4. — *Showing Percentage Removal of B. Coli by Different Methods of Sewage Treatment. (Filters Nos. 1, 5, 6, 9A, 10 and 100 are Sand Filters, Filters Nos. 103, 175, 176 and 221 are Contact Filters, and Filters Nos. 135 and 136 are Intermittent-continuous Filters.)*

SAMPLES FROM —	Dec., **1903.**	Jan., **1904.**	Feb., **1904.**	March, **1904.**	April, **1904.**	May, **1904.**	June, **1904.**	Average.
By Septic Tank A, . .	63.60	45.90	57.10	71.10	–*	40.00	46.30	46.40
By Filter No. 1, . .	93.37	99.54	96.99	86.54	95.42	99.99	99.77	96.76
5, . .	98.00	93.14	93.33	93.18	99.04	99.81	99.89	96.96
6, . .	–	99.74	98.17	98.95	96.14	99.99	99.43	99.29
9A, . .	98.18	93.95	99.44	99.30	99.64	99.99	99.89	98.54
10, . .	99.99	99.97	99.82	99.47	99.94	99.99	–	99.92
100, . .	97.25	99.67	98.17	99.15	96.65	99.25	97.87	98.33
103, . .	56.75	80.49	64.02	89.69	81.41	82.29	–	76.40
135, . .	99.83	99.69	96.86	99.39	99.66	99.03	–	99.09
136, . .	98.36	98.05	94.77	96.68	97.83	96.18	–	96.96
175, . .	4.20	16.60	–*	–	–	–	–	–
176, . .	73.36	64.14	78.69	88.11	13.25	70.55	90.32	71.60
221, . .	77.27	65.98	64.05	71.15	45.78	37.50	–*	48.80

* Number of B. coli in effluent higher than in applied sewage.

The determinations of the species of bacteria in sewage and in the effluents of sewage filters, further than determinations of the passage of disease germs through these filters, while of interest, are of little practical value unless they are combined with studies of the biochemical reactions which these bacteria produce in sewage. During 1903–1904 extensive studies were made to determine what biochemical reactions occur in different methods of sewage disposal, what types of bacteria are responsible for these reactions, and the relative numbers of bacteria of the various biochemical groups, together with the amount of change which each type of bacteria is able to produce and the rapidity with which it causes that change.

The detailed results of these investigations are too long for insertion here, and have been separated into two papers, one describing new methods of biochemical analysis, with a discussion of their practical application in the study of sewage disposal systems, and the other dealing with the theoretical and biochemical aspects of the sewage disposal problem.*

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* "The Functions of Various Types of Bacteria in the Purification of Sewage." H. W. Clark and Stephen DeM. Gage. Engineering News, Vol. liii, 1905, page 27. "Contribution to the Biochemistry of Sewage Purification; the Bacteriolysis of Peptones and Nitrates." Stephen DeM. Gage. Technology Quarterly, xviii, 1905, page 5. Journal of the American Chemical Society, xvii, 1905, page 327. A complete bibliography of the biochemistry is included in the latter paper, pages 12 to 21 inclusive.

Of the biochemical functions of the bacteria concerned in sewage disposal, the most important are the power to peptonize or liquefy the organic matter in suspension, the power to break down the soluble proteids into ammonia, and the power to convert this ammonia into some stable product, such as nitrates, or into free nitrogen. Denitrification, while in a measure a retrograde process, undoubtedly does occur in sewage filters, and the secondary reactions between the reduction products of nitrates and the intermediate products of peptonization, leading, as they do, to the liberation of nitrogen as the lower oxides and as free nitrogen, are probably of more importance than has formerly been thought to be the case. The studies previously presented in this report showing that in sand filters only about 55 per cent. of the applied nitrogen appears as nitrates in the filter effluents, and results presented in this and previous reports, showing the great disappearance of nitrogen in the operation of contact filters, prove the truth of this statement.

Some three hundred cultures of bacteria common in sewage and in the effluents of sewage filters, carefully selected from the colonies on gelatin plates in such a manner as to represent all of the kinds of bacteria in the sample under analysis, have been examined to determine their ability to produce ammonia in pepton solution, to reduce nitrates in nitrated pepton solution, and to liquefy organic matter in the form of gelatin during a uniform incubation period of seven days. From the data thus accumulated it has been possible to compute the percentage of the total number of bacteria in the individual samples which possess these functions, and to determine the relation between the peptonizing power of these bacteria and their ammonifying and denitrifying powers. That a considerable percentage of the bacteria commonly found in sewage and in the effluents and material from sewage filters is able to produce these reactions to a greater or less extent is shown by the following table: —

Distribution of Ammonifying and Denitrifying Bacteria.

Source.	Percentage of Total Bacteria which —	
	Ammonify Pepton.	Reduce Nitrates.
Sewage,	90	70
Septic sewage,	56	59
Effluent of contact filters,	60	61
Effluent of trickling filters,	59	71
Effluent of sand filters,	70	70
Sand from sewage filters,	90	70

Comparing the results obtained with cultures which liquefied the gelatin with those which did not liquefy, it is found that the liquefiers have an average ammonifying power nearly twice as great as the non-liquefiers, and that they have a denitrifying power about three times as great as shown by the total reduction of nitrates and nearly four times as great as shown by the production of nitrites. In each group of cultures, both liquefying and non-liquefying, some were found which caused large changes in the nitrogen content and others which caused no change whatever. A study of the individual analyses, however, reveals that, while 30 per cent. of the non-liquefying bacteria were unable to reduce nitrates, only 8 per cent. of the liquefying cultures failed in that function. Again, 32 per cent. of the non-liquefying cultures did not produce nitrites in the nitrate solution, and the same percentage of cultures failed to show any ammonia production in the pepton solution. On the other hand, the number of liquefying cultures which failed to produce nitrites was 15 per cent., or less than one-half as many; and the percentage of cultures which failed to break down pepton into ammonia was only 2 per cent., or one-eighth as many as with the non-liquefying cultures. In other words, as shown by the amount of change and the percentage of cultures reacting, the liquefying cultures are much more active in causing putrefaction and denitrification than are the non-liquefying cultures. The comparative results obtained with liquefying and non-liquefying cultures have been grouped in the following table: —

Table showing the Relation between Peptonization, Ammonification and Denitrification.

	Cultures which do not liquefy Gelatin.	Cultures which do liquefy Gelatin.
Number of cultures examined,	44	113
Per Cent. of Cultures which failed to —		
Reduce nitrates,	30.0	8.0
Produce nitrites,	32.0	15.0
Produce ammonia from pepton,	32.0	2.0
Amount of Nitrates reduced, Parts per 100,000.		
Average,	1.8	5.3
Maximum,	7.0	9.6
Minimum,	0.0	0.0
Amount of Nitrites produced, Parts per 100,000.		
Average,	1.6	6.1
Maximum,	11.0	12.0
Minimum,	0.0	0.0

Table showing the Relation between Peptonization, Ammonification and Denitrification — Concluded.

Amount of Ammonia produced from Pepton, Parts per 100,000.

	Cultures which do not liquefy Gelatin.	Cultures which do liquefy Gelatin.
Average,	0.4	0.7
Maximum,	1.9	5.2
Minimum,	0.0	0.0

Thirty cultures of bacteria, representing the forms most commonly found in sewage and in the effluents from sewage filters, have been studied carefully, to determine the character and amount of change which they will produce in the nitrogenous contents of solutions containing nitrogen in the form of commercial pepton and potassium nitrate. Two solutions, one containing 1 per cent. of pepton and the other 1 per cent. of pepton and nitrogen as nitrates, equivalent to 12 parts of nitrogen per 100,000, were seeded with each of the test organisms, and were kept under observation for three weeks or more. Determinations of the total amount of nitrogen were made on all cultures at the beginning and end of the period of study, and daily determinations were made of the amount of nitrates, nitrites and ammonia present in each. It has been assumed that the reactions produced by bacteria under these conditions might well be produced by the same kinds of bacteria in sewage during its process of purification, should favorable conditions occur. That this assumption is correct will be shown further on.

From the results obtained in this study it becomes possible to state definitely that bacteria common in sewage purification are able to produce ammonia from organic matter, to reduce nitrates to nitrites to ammonia and probably to elementary nitrogen, to liberate nitrogen from solutions of organic matter, either with or without the presence of nitrates or its reduction products, and to fix atmospheric nitrogen, — all of which reactions have been noted by other observers, but about which there has been more or less controversy. Many sewage bacteria also produce the lower oxides of nitrogen as reduction products of nitrates, which oxides play an important part in the further decomposition of the organic matter in solution, either through catalytic action or by direct chemical reaction.

Furthermore, certain of these bacteria may produce an oxide or at least a compound of nitrogen intermediate between nitrates and nitrites, which apparently has not been noted hitherto.

The amount of ammonia produced by the different cultures and the rate of ammonification varied considerably, some of the cultures reacting as early as the fourth day, while other cultures, which eventually reacted strongly, did not begin to ammonify until after periods of ten to fourteen days. Similar phenomena were noted with regard to the reaction of the cultures on nitrates. Some reduced the nitrates rapidly and completely, some denitrified slowly, some reacted only after a fairly long period of incubation, and others caused no change. Some cultures were able to reduce the nitrates to nitrites, ammonia and elementary nitrogen continuously from the start, while with other cultures the reduction to these various bodies occurred consecutively, and with still others one or another of the reduction products was not formed during the period over which the examination of the cultures extended. In a few instances nitrites were produced in quantities far greater than the amount of nitrates; and, if the results are not in error, this can be explained only on the supposition that a direct oxidation or nitrification occurred, caused either by bacterial action or by some undetermined secondary reaction.

In the following table are shown the results of analyses of the various cultures made at the end of their period of incubation. By the use of the determinations of nitrates, nitrites and ammonia, and of the values for total nitrogen by the Kjeldahl method, we have been able to compute the total gain or loss of nitrogen by each culture, and to compare the change in the organic nitrogen with the change in the nitric nitrogen. Eighteen of the thirty cultures showed a loss of nitrogen in the pepton solution, and twelve of the cultures showed a gain in nitrogen. In the nitrated solution, fifteen of the cultures showed a loss of nitrogen, and thirteen showed a gain. Eighteen of the cultures agreed as to gain or loss of nitrogen as determined in the two solutions. Two of the cultures showed no change in the nitrate solution, and ten of the cultures showed a gain or loss of nitrogen in the pepton solution, when the reverse was true in the nitrate solution. With eight of these ten cultures, the gain or loss of nitrogen in one solution or the other was 0.5 part per 100,000 of nitrogen or less, this being the probable limit of error of the Kjeldahl method.

The maximum gain in nitrogen in the pepton solution was 12.0 parts, and the maximum gain in the nitrate solution was 12.1 parts. The greatest losses of nitrogen were 5.0 parts in the pepton solution and 6.6 parts of nitrogen in the nitrate solution. Assuming that the error of the methods is 0.5 part per 100,000, twenty-two of the thirty cultures gained or lost more than this amount in the pepton solution and twenty-three gained or lost more than this amount in the nitrate solution. Comparing the reduction of organic nitrogen by the same culture in the two solutions, with twenty cultures a greater reduction in total nitrogen occurred in the nitrate solution than in the pepton solution, either through increased activity of the bacteria in the presence of nitrates, or, as is more probable, through secondary reactions between the decomposition products of the nitrates and organic nitrogen.

Comparing the reduction of organic nitrogen with the reduction of nitric nitrogen, we find that, of twenty-four cultures which showed a reduction of organic nitrogen of 0.5 part or more, seven failed to reduce nitrates; while of the six cultures which did not cause any material reduction in the organic nitrogen, three were able to produce a decided reduction of nitrates.

Table showing the Gain or Loss of Nitrogen produced by Cultures of Bacteria in Organic Solution with and without the Presence of Nitrates.

[Parts per 100,000.]

CULTURE.	PEPTON SOLUTION.			NITRATE PEPTON SOLUTION.				
				REDUCTION OF —		DETERMINED AS —		
	Reduction of Organic Nitrogen.	Determined as Ammonia.	Gain (+) or Loss (—) of Total Nitrogen.	Organic Nitrogen.	Nitric Nitrogen.	Ammonia.	Nitrites.	Gain (+) or Loss (—) of Total Nitrogen.
10	6.0	18.0	+12.0	8.3	2.7	12.0	0	+1.0
16	3.5	7.5	+4.0	0.4	0	1.0	0	+0.6
8	0	2.3	+2.3	0	2.6	2.3	0.8	+0.5
23	0	0.7	+0.7	0.1	0	0.5	0	+0.4
4	0	0.6	+0.6	4.5	6.0	7.5	5.0	+2.0
1	1.6	2.1	+0.5	2.2	0	3.8	0.1	+1.7
29	2.3	2.7	+0.4	3.2	1.5	1.9	4.5	+1.7
12	2.1	3.8	+1.7	2.3	0	1.9	0	—0.4
9	1.1	2.3	+1.2	2.8	5.3	3.8	3.0	—1.3
18	1.8	2.2	+0.4	2.4	2.7	1.8	2.6	—0.7
11	0.1	0.5	+0.4	4.5	6.0	5.0	2.8	—2.7
13	3.3	4.2	+0.9	1.4	0	1.4	0	0
6	6.8	1.8	—5.0	0	1.0	0.6	0.3	—0.1
17	3.0	0.2	—2.8	3.0	2.3	3.0	2.2	—0.1
7	4.5	2.2	—2.3	3.2	3.5	1.8	1.6	—3.3
33	2.0	0	—2.0	2.2	1.5	0.6	0.5	—2.6
24	6.2	4.8	—1.4	8.4	4.5	8.6	1.8	—2.5
36	1.1	0.1	—0.7	1.5	0	0.6	0	—0.9
40	2.9	1.5	—1.4	2.8	2.5	1.9	2.2	—1.2
27	1.5	0.9	—0.6	2.5	0	0.6	0	—1.9
32	5.3	4.8	—0.5	9.0	1.5	3.9	0	—6.6
26	0.4	0.2	—0.2	1.6	0	0.7	0.1	—0.8
38	0.6	0.4	—0.2	2.1	0	1.1	0.9	—0.1
34	1.7	0	—1.7	4.1	2.5	1.7	17.0	+12.1
2	2.4	1.1	—1.3	0	0	0.9	0.1	+1.0
31	3.2	2.4	—0.8	5.5	11.0	3.9	15.0	+2.4
41	2.3	1.8	—0.5	3.1	2.5	2.1	4.0	+0.5
30	0.5	0.3	—0.2	0	2.5	4.7	0	+2.2
25	0.5	0.3	—0.2	4.9	9.0	2.7	15.0	+3.8
22	3.1	3.0	—0.1	2.3	2.1	2.6	1.8	0

In order to make these biochemical studies of practical value as methods for sewage analysis, it is necessary that they be expressed quantitatively and according to some definite formula. The liability of a change in the character of the sewage by the action of its bacterial contents or by the action of the bacteria in the filter depends upon the number of bacteria at work and upon the individual power of those bacteria to produce the changes in question, this being called the potential of the sewage under the given conditions. The quantitative expression of the potential can be called the coefficient, this coefficient being the product of the amount of chemical change which the individual bacteria are able to produce in a definite time by the numbers of bacteria which are producing that reaction. For convenience, the amount of change produced in a solution containing 0.1 per cent. of pepton, a solution containing 0.1 per cent. of pepton and potassium nitrate equivalent to 12 parts per 100,000, and in standard gelatin, during seven days' incubation at 20° C., has been selected as a standard, and the number of bacteria in the sample has been expressed as millions of bacteria per cubic centimeter. Thus the numerical expression of the total ability of the bacteria in a sample to produce ammonia from organic matter is the ammonifying coefficient; of the total ability to reduce nitrates is the denitrifying coefficient; and the total ability to liquefy albuminous matter is the liquefying coefficient.

The term nitrogen-liberating coefficient used here is the expression of the ability to liberate nitrogen from nitrates, and is independent of the total gain or loss of organic nitrogen previously discussed. The determination of these coefficients is as follows: each colony on a gelatin plate from any sample represents an aliquot portion of the total number of bacteria in the sample, and the amount of ammonia produced from organic matter by this culture, expressed as parts of ammonia per 100,000, is the ammonifying power of the culture. The ammonifying power of the culture multiplied by the estimated number of bacteria of that type in the sample expressed as millions of bacteria per cubic centimeter becomes the ammonifying coefficient of the type of bacteria, and the sum of the ammonifying coefficients of all the types in a given sample becomes the ammonifying coefficient for the sample. The denitrifying coefficient and the nitrogen-liberating coefficient are determined in a similar manner. The liquefying coefficient of each type of bacteria is obtained by multiplying the depth of liquefaction in millimeters produced in gelatin by the culture inoculated onto the surface of the gelatin, in seven days' incubation at 20° C., by the number of millions of bacteria of that type in the sample; and the sum of the liquefying coefficients of the different types of bacteria in the sample is the liquefying coefficient of the sample.

During the first six months of 1904, a considerable number of sewage and sewage effluents were examined by these methods. Inspecting the results of these examinations as compiled in the following table, it will be noted first that there is considerable variation in the coefficients as determined for Lawrence sewage at different times, and also that the coefficients for the Andover sewage are much greater than those for the Lawrence sewage. Taking the septic sewages, we find that there is considerable increase in the ammonifying coefficients over those of the sewage entering the septic tanks, in both Septic Tanks A and D-1, in which the sewage at this time was receiving from twenty to twenty-four hours' storage. With the septic sewages D-1, D-2, D-3, D-4 and D-5, which were receiving respectively one, two, three, four and five days' storage, an interesting fact is noticed, in that the ammonifying, denitrifying and nitrogen-liberating coefficients were steadily reduced with increased storage. Comparing the effluents of contact Filters Nos. 103, 175 and 176, with the effluents of intermittent-continuous Filters Nos. 135, 136 and 189, the variation in free ammonia as determined by chemical analysis agrees fairly well with the variation in the ammonifying coefficients. In these two types of filters the nitrate-reducing and nitrogen-liberating coefficients of the contact filters, in which the action is more or less anaerobic, are many times higher than those of the intermittent-continuous filters, in which the action is almost entirely aerobic.

Inspecting the biochemical and chemical analyses of samples from the out-of-door Filters Nos. 1 to 10 inclusive, collected during the winter months, we find in nearly every case high ammonifying coefficients accompanied by high free ammonia, as determined by chemical analysis, and high denitrifying coefficients correlated with considerable free ammonia and nitrites and low nitrates.

Comparing the results obtained from these winter samples with the results obtained from samples examined during the latter part of June and the early part of July, when the filters had recovered from the cold weather and were doing first-class work, we find that the effluents from Filters Nos. 1, 2, 5B, 6 and 9A, which showed some ammonifying power when examined in the winter, had lost this power when nitrification had become more active within them. The effluents from Filters Nos. 1, 2, 5B, 6 and 9A, all showed considerable power to reduce nitrates and liberate nitrogen during the cold weather, but such power was lacking when examined again in warm weather. The effluents from Filters Nos. 4 and 10, which continued to nitrify actively during the winter, did not show any ammonifying, denitrifying or nitrogen-liberating powers, either winter or summer.

These results are further evidence that during exceptionally cold weather the nitrifying bacteria are more or less inactive, and that much of the change going on in a filter is accomplished by bacteria of other types which are apparently capable of performing their work at low temperatures. The results of the determinations of the various coefficients, together with a portion of the results of chemical analyses of the same samples, are shown in the following table: —

Table showing Results of Biochemical Examinations of Sewages and the Effluents from Sewage Filters.

SAMPLES FROM —	1904.	BACTERIAL AND BIOCHEMICAL ANALYSIS.						CHEMICAL ANALYSIS (PARTS PER 100,000).		
		Bacteria per Cubic Centimeter.	Per Cent. of Bacteria which liquefy Gelatin.	Ammonifying Coefficient.	Denitrifying Coefficient.	Nitrogen-liberating Coefficient.	Liquefying Coefficient.	Free Ammonia.	Nitrites.	Nitrates.
Station sewage, . . .	Feb. 25,	2,350,000	8.5	0.28	2.03	1.83	–	4.80	–	–
Station sewage, . . .	Mar. 8,	5,650,000	1.8	0.61	1.96	0.70	–	3.50	–	–
Station sewage, . . .	June 27,	1,750,000	7.0	1.08	6.70	2.14	–	6.60	–	–
Sewage for Septic Tank A,	Feb. 29,	4,500,000	3.3	1.18	6.62	5.38	–	3.80	–	–
Septic sewage A, . .	Feb. 29,	2,700,000	2.8	1.39	5.14	3.27	–	4.00	–	–
Sewage for Septic Tank D,	Mar. 24,	4,150,000	2.4	0.65	2.65	1.32	–	4.90	–	–
Septic sewage D–1, . .	Mar. 24,	4,150,000	6.1	1.47	2.88	1.74	–	7.00	–	–
Septic sewage D–2, . .	Mar. 24,	1,000,000	10.0	0.45	1.43	1.14	–	6.50	–	–
Septic sewage D–3, . .	Mar. 24,	860,000	9.3	0.56	1.35	0.88	–	6.50	–	–
Septic sewage D–4, . .	Mar. 24,	700,000	1.4	0.50	0.75	0.59	–	5.80	–	–
Septic sewage D–5, . .	Mar. 24,	1,300,000	4.6	0.22	1.60	0.53	–	5.50	–	–
Andover sewage, . .	June 9,	3,000,000	7.0	1.51	13.43	6.98	2.21	3.30	–	–
Effluent of Filter No. 103, .	Mar. 16,	590,000	7.6	0.20	1.02	0.31	–	1.56	.0070	0.51
" " 175, .	Mar. 1,	1,350,000	6.7	0.17	1.33	1.21	–	0.86	.1000	4.10
" " 176, .	Mar. 1,	1,040,000	3.9	0.38	1.75	1.34	–	3.20	.0200	0.00
Effluent of Filter No. 135, .	Mar. 16,	150,000	40.0	0.11	0.27	0.16	–	0.46	.0060	2.93
" " 136, .	Mar. 16,	250,000	46.0	0.67	0.67	0.56	–	1.20	.0100	2.09
" " 189, .	Mar. 8,	800,000	7.5	0.11	0.46	0.27	–	2.81	.0120	0.91
" " 222, .	June 9,	1,650,000	6.0	0.63	4.88	2.78	1.42	3.00	.0000	0.05
Effluent of Filter No. 1, .	Feb. 25,	550,000	5.5	0.03	0.44	0.43	–	4.16	.0040	0.77
" " 1, .	July 1,	3,000	7.0	0.00	0.01	0.00	0.04	0.04	.00[illegible]0	4.62
" " 2, .	Feb. 25,	21,300	2.2	0.00	38.46	0.03	–	1.75	.0048	0.07
" " 2, .	July 6,	20	45.0	0.00	0.00	0.00	0.00	0.76	.0104	4.28
" " 4, .	Feb. 25,	43	46.4	0.00	0.00	0.00	–	0.03	.0006	1.18
" " 4, .	July 1,	60	3.0	0.00	0.00	0.00	0.00	0.70	.0004	5.38
" " 5, .	Feb. 25,	300,000	10.0	0.07	0.21	0.17	–	2.90	.0100	1.60
" " 5, .	July 1,	1,500	17.0	0.00	0.00	0.00	0.01	0.30	.0004	7.14
" " 6, .	Mar. 11,	82,500	8.5	0.04	0.12	0.11	–	3.20	.0020	0.84
" " 6, .	July 1,	2,250	11.0	0.00	0.00	0.00	0.02	0.02	.0002	5.24

Table showing Results of Biochemical Examinations of Sewages and the Effluents from Sewage Filters — Concluded.

SAMPLES FROM —	1904.	BACTERIAL AND BIOCHEMICAL ANALYSIS.						CHEMICAL ANALYSIS (PARTS PER 100,000).		
		Bacteria per Cubic Centimeter.	Per Cent. of Bacteria which liquefy Gelatin.	Ammonifying Coefficient.	Denitrifying Coefficient.	Nitrogen-liberating Coefficient.	Liquefying Coefficient.	Free Ammonia.	Nitrites.	Nitrates.
Effluent of Filter No. 9, .	Mar. 11,	100,000	10.0	0.01	0.13	0.06	–	2.00	.0060	2.22
" " 9, .	June 27,	18	100.0	0.00	0.00	0.00	–	0.02	.0000	3.75
" " 10, .	Mar. 11,	6,800	22.2	0.00	0.01	0.01	–	4.60	.0026	3.57
" " 10, .	July 1,	75	58.0	0.00	0.00	0.00	0.01	0.03	.0002	5.85
" " 100, .	Mar. 1,	80,000	5.6	0.07	0.04	0.02	–	0.96	.0060	0.77

To summarize the results of the biochemical studies, it may be said that the amount of purification which a sewage will undergo in a given time depends on the number of bacteria at work and on the power of the individual bacteria to perform that work; the process of purification being accomplished by the bacteria present in the sewage, working jointly with the bacteria which have found lodgment in the filtering material. The chemical changes which may take place in the sewage in the process of purification may be divided into five groups, as follows: (1) putrefaction, that is, the breaking down of the complex organic matter into simpler forms; (2) nitrification and oxidation, that is, the oxidation of nitrogenous matter into nitrites and nitrates, and of carbonaceous matter into carbonates and carbonic acid gas; (3) denitrification, that is, the breaking down of nitrites and nitrates into simpler nitrogenous compounds; (4) nitrogen liberation, that is, the formation of gaseous nitrogen either by direct bacterial action or by secondary reactions between the reduction products of putrefaction and denitrification; (5) fixation of atmospheric nitrogen, that is, the fixation of molecular nitrogen from the air in the form of ammonia.

Of these reactions, putrefaction and nitrification are to be encouraged. It is an open question whether denitrification should be encouraged or not, depending on whether the liberation of nitrogen incidental during this process overbalances the effect of the decrease in active nitrification.

Nitrogen liberation is desirable provided it can be made to take place in such a manner as to leave the effluent of a filter in a stable and highly oxidized condition, while the fixation of atmospheric nitrogen in a sewage filter is to be avoided if possible. These processes probably all go on to a greater or less extent in sewage filters of the various types. If a filter is so constructed and operated that oxidizing processes are active throughout the entire depth, the reduction of nitrates is largely prevented, and a large proportion of the nitrogen in the applied sewage will appear in the effluent as nitrates. If, however, the construction and operation of the filter is such that both oxidizing and reducing actions occur, or the reducing action predominates, much nitrogen will be liberated. The effluents of intermittent-continuous filters in good operation contain much of the nitrogen applied, while the effluents of contact filters in good operation show a large disappearance of nitrogen ; and this is shown not only by computations of the amount of nitrogen applied and appearing in the effluent of such filters as determined by chemical analyses, but also by the results of the biochemical examination of the effluents from the various classes of filters.

The effluents of intermittent sand filters in good operation also contain considerable portions of the applied nitrogen. During the cold weather, however, nitrification may become inert in filters of this type ; and, while the effluents may remain of good appearance, high free ammonia and low nitrates will prevail, combined with a considerable loss of nitrogen.

Loss of Inorganic Nitrogen in Contact Filtration and Intermittent-continuous Filtration during 1904.

On page 213 of the report of 1902, a chapter is given with this heading, and in connection with the chapter on "Storage, Oxidation, etc., of Nitrogen," given in this report, and the chapter upon "Biochemistry of Sewage," the following table is of interest. This table shows that a much greater percentage of the inorganic nitrogen in the sewage applied to intermittent-continuous filters appears oxidized in the effluent of such filters than appears in the effluent of contact filters ; in other words, it shows that contact filtration is always favorable to the growth of nitrogen-liberating bacteria, and results in the disappearance of a considerable per cent. of the nitrogen applied to the filters.

Contact Filters.

Filter Number.	Per Cent. of Applied Inorganic Nitrogen appearing in Effluents.	Per Cent. of Inorganic Nitrogen Lost.	Filter Number.	Per Cent. of Applied Inorganic Nitrogen appearing in Effluents.	Per Cent. of Inorganic Nitrogen Lost.
103, . . .	43	57	237, . . .	85	15
175, . . .	68	32	251, . . .	71	29
176, . . .	56	44	Average, .	61	39
221, . . .	45	55			

Intermittent-continuous Filters.

135, . . .	84	16	235, . . .	80	20
136, . . .	76	24	236, . . .	87	13
233, . . .	84	16	247, . . .	67	33
234, . . .	89	11	Average, .	81	19

Determinations of Turbidity and Sediment.

Since the establishment of the station all records of the amount of matter causing turbidity, or depositing as sediment, in water, sewage, the effluents of sewage filters, etc., have been simply word descriptions; that is to say, the turbidity or sediment has been called "very slight," "slight," "decided," "heavy," etc. Various methods of determining turbidity have been formulated in the past few years, none of which, however, seemed entirely applicable to the station work.

The U. S. Geological Survey has adopted for use in its work the silica or diatomaceous earth standard of Hazen and Whipple.*

This standard is well suited for field work. It is not as well suited for laboratory work, especially in sewage purification studies; and one of its chief defects, as with other standards, is in the failure of the material used to match in color and other physical characteristics the material causing turbidity and sediment in the effluents of sewage filters. To obviate this difficulty, and yet obtain a clearer idea of the actual and relative amount of matter in suspension or appearing as sediment in the effluents of the sewage filters of various types, a standard has been used at the station during a large part of 1904, the basis of which is the actual material passing down through contact or intermittent-continuous sewage filters. This material is taken from the effluent of a filter in good operation, that is, in a state of active nitrification. As collected from the effluent of such a filter, this material is fairly constant in composition, stable, and quite uniform in its color and general physical characteristics. When dried, its loss upon ignition is generally not more than 30 per cent. of its total weight. With the small amounts used in making the standards, slight variations in the exact proportion of mineral and organic matter present have little influence in causing any appreciable variation in uniformity of the standard. Standards made from this matter match closely, in color and appearance, matter in suspension in the effluents of most sewage filters and in many pond and river waters in the New England States. It gives a more nearly correct idea of the actual amount of matter in suspension in a given volume of filter effluent in a sample bottle than can be determined with other standards in use. In making the standard, it is necessary to keep in a moist condition the material collected from the filters, as when dried it changes its character somewhat, does not become again so well divided into small particles when placed in water in the standard bottles, and higher standards must be taken to match turbidities than actual determinations of matter present in effluents under examination show to be correct. To make up the standard, the amount of sediment present in a given volume of water, thick with the material, is determined, and a sufficient volume of this water is then taken to give the weights of material necessary per liter in the different standards. For instance, a bottle full of the wet sediment used for making standards at the Lawrence Experiment Station contained .4255 gram of suspended matter in 100 cubic centimeters of water; and from this bottle, to make the standard 10.0, enough of this liquid was taken to give 0.1 gram of suspended matter per liter in this standard, other standards being made by taking proportional volumes. The weights and standards are as follows: —

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* As stated by them, "this standard of turbidity shall be such that a water which contains 100 parts of silica per million in such a state of fineness that a bright platinum wire 1 millimeter in diameter can just be seen when the centre of the wire is 100 millimeters below the surface of the water and the eye of the observer is 1.2 meters above the wire, the observation being made in the middle of the day in the open air, but not in sunlight, and in a vessel so large that the sides do not shut out the light so as to influence the results. The turbidity of such a water shall be 100. . . . When the turbidity is below 7, this method cannot be used, and comparisons should be made with the silica standard, properly diluted in bottles or tubes, as described by Whipple and Jackson in Technology Quarterly, Vol. XII., No. 4, December, 1899." (Division of Hydrography, Circular No. 8.)

Weight of Material (Grams per Liter).	Standard of Turbidity (Parts per 100,000).	Weight of Material (Grams per Liter).	Standard of Turbidity (Parts per 100,000).	Weight of Material (Grams per Liter).	Standard of Turbidity (Parts per 100,000).
.001	0.1	.04	4.0	.10	10.0
.005	0.5	.07	7.0	.15	15.0
.01	1.0				

To the set of standards, two or three cubic centimeters of a 5 per cent. solution of formaldehyde are added, to prevent change by bacterial action. The standards should be renewed every two or three months, as the matter after a certain period has a tendency to gather in larger aggregations of particles than when the standards are first made up.

The most convenient method of using the standards is to have a set made up in bottles of the same capacity as those in which samples are collected, in order that a direct comparison may be made. In the Lawrence work, gallon bottles are used.

In tables on subsequent pages, showing the average analyses of the effluents of the various sewage filters, the results obtained by the use of this standard are given. These results are of great value, in that they aid in giving a clearer idea of the appearance of these effluents than otherwise can be obtained from tables of analyses. Studying the tables as given in a subsequent portion of this report, it will be seen that from the beginning of July, when the standard began to be used, the highest average turbidity of the effluent of Filter No. 1 for any month was 0.8. That is to say, this effluent even in that month contained on an average only about .008 of a gram of matter in suspension in one liter of water. The effluent of Filter

No. 2 was free from turbidity for three months out of the six during which this standard was used; and during the three months when turbidity readings were obtained. the amount of matter in suspension averaged only .001 of a gram per liter. Throughout six months the effluent of Filter No. 4 did not contain an amount of matter in suspension that could be detected when compared with the lowest standard in use. The highest average turbidity for Filter No. 5B was 2.8, indicating the presence of .028 of a gram of matter in suspension in one liter of effluent. The effluent of Filter No. 6 approximated in quality in this respect the effluents of Filters Nos. 2 and 4, as did also the effluents of Filters Nos. 9A and 10.

The great difference in the quality of the effluents of sand intermittent-continuous, and contact filters, in regard to matters in suspension, is clearly shown by this standard. Turbidities six to fifteen times as great as the turbidities of Filters Nos. 2, 4, 6 and 9 are shown by examination of the tables giving analyses of the effluents of intermittent-continuous Filters Nos. 135 and 136. and the effluents of contact Filters Nos. 175 and 176, these four filters being the best four filters of these two classes in operation at the station.

The standard is of great value also in determining the rapidity with which the matter in suspension in the effluents of sewage filters settles; that is to say, the readings of turbidity and sediment made at different periods after the time of collecting the sample indicate clearly the percentage of the amount of matter primarily in suspension appearing at each reading as suspended matter and as sediment.

Comparisons have been made of the results obtained by this standard with the results of word descriptions formerly used. and result as follows: —

Of 70 turbidity determinations described as "great." 85 per cent. of the numerical readings were 5.0 parts or over; of 62 described as "decided," 71 per cent. were included between numerical readings of 2.0 and 5.0, 3 per cent. were over 5.0 parts and 26 per cent. were under 2.0 parts. Of 36 determinations described as "slight," 92 per cent. of the numerical readings were included between 0.2 and 2.0; 8 per cent. were under 0.2 parts. Of 44 sediment determinations described as "great," 98 per cent. of the numerical readings were 5.0 or over. Of 50 determinations described as "decided," 72 per cent. were included between numerical readings of 2.0 and 5.0 parts; 18 per cent. were over 5.0 parts and 10 per cent. under 2.0 parts. Of 44 determinations described as "slight," 84 per cent. of the numerical readings were included between 0.2 and 2.0 parts; 14 per cent. were over 2.0 parts and 2 per cent. were under 0.2 part.

EXPERIMENTS DETERMINING THE AMOUNT OF TIME TAKEN BY SEWAGE TO PASS THROUGH INTERMITTENT-CONTINUOUS FILTERS OF COARSE MATERIALS OPERATED AT HIGH RATES.

During the year a study has been made with each one of the intermittent-continuous filters, to show the time taken for the passage of sewage through these filters; this being done in order to gain information in regard to the rapidity of nitrification within such filters. The experiments were made in the manner followed at the experiment station in previous years with filters of different classes; that is to say, sewage containing a known amount of salt has been applied to the filter, and careful determinations made of the chlorine in the effluent of the filter before, during and after the period of application of this salt sewage.

With Filter No. 135, containing 12 feet in depth of broken stone, and operated at the time of the experiment at the rate of 1,500,000 gallons per acre daily, it was about one hour after the application of salt sewage before any of it appeared in the effluent. From this time the chlorine increased rapidly, until at the end of three hours the effluent contained 92 per cent. as much chlorine as in the applied sewage; the highest amount found. With Filter No. 136, constructed of the same kind and size of filtering material, but operating at a rate 70 per cent. greater than Filter No. 135, the maximum amount of chlorine present in the effluent was reached within two hours after the application of salt sewage.

Further experiments of the same kind were made with Filters Nos. 247 and 248, constructed of broken stone, and Filters Nos. 233, 234, 235 and 236, constructed of clinker. Filter No. 247 contains 5 feet in depth of broken stone, and at the time the experiment was made the rate of operation was 1,000,000 gallons per acre daily. An increase in the amount of chlorine in the effluent of this filter was appreciable at the end of fifteen minutes, and it increased steadily for about two hours, when the amount became constant, the highest amount found in the effluent being 90 per cent. of the amount applied. With Filter No. 248, containing 8 feet in depth of broken stone, the amount of chlorine present in the effluent increased appreciably at the end of half an hour, and after about two hours became constant, the maximum amount found in the effluent being about 81 per cent. of the amount in the sewage applied. Filters Nos. 233, 234, 235 and 236 are constructed of clinker, Nos. 233 and 235 being constructed of coarse clinker, and Nos. 234 and 236 of a finer grade of clinker. The rate of operation of each of these filters was, at the time of experiment, 1,000,000 gallons per acre daily. With Filter No. 233, containing 5 feet and 9 inches in depth of coarse clinker, the chlorine in the effluent increased appreciably in from fifteen to twenty minutes, and from that time steadily, until at the end of six hours it was fairly constant. Filter No. 234, of the same grade of material, and only 3 feet 10 inches in depth, showed an increase of chlorine in its effluent in fifteen minutes or less; and the amount became constant one hour from the beginning of the application of the salt sewage. In Filter No. 233 the highest chlorine found in the effluent was 80 per cent. of that in the applied sewage; and in Filter No. 234, 86 per cent. of that in the applied sewage. The deeper filter of fine clinker did not show an increase of chlorine in the effluent until about one and one-half hours from the beginning of application of salt sewage, and the amount found slowly increased for fourteen hours before it became constant. With the shallower filter of fine clinker, the increase in chlorine could be noted at the end of one and one-half hours; it gradually increased for six hours before becoming constant. The maximum chlorine in the effluent of Filter No. 235 was 72 per cent. of the chlorine in the salt sewage; and in the effluent of Filter No. 236, 79 per cent. It was noticeable that in none of the experiments did the chlorine in the effluent become equal to the chlorine in the applied salt sewage, although this salt sewage was applied for many hours; this being due to the fact that a certain volume of sewage previously applied is held even in these filters of coarse material, and this, being slowly given up and mingling with the salt sewage applied, reduces its chlorine content. It is also noticeable, from the greater length of time taken for the chlorine in the effluent of the clinker filters to reach a constant amount, that these filters hold a much greater percentage of sewage in their pores than the filters of broken stone; this being due to the porosity and uneveness of the material, and has, of course, a beneficial effect upon the purification effected by the filters. The following table shows the effect of depth, material in and time of passage of the sewage through these filters upon the nitrification occurring within them: —

FILTER NUMBER.	Depth.		Material.	Average Rate, 1904 (Gallons per Acre Daily).	Time of Passage of Sewage (Hours).	Nitrates (Parts per 100,000).
	Ft.	In.				
135, ...	12	0	Broken stone, .	1,150,000	3	2.95
136, ...	12	0	Broken stone, .	1,938,000	2	2.05
247, ...	5	0	Broken stone, .	925,500	2	0.52
248, ...	8	0	Broken stone, .	963,400	2	2.12
233, ...	5	9	Coarse clinker,	885,000	6	1.24
234, ...	3	10	Coarse clinker,	949,000	1	0.73
235, ...	5	9	Fine clinker, .	896,500	14	2.20
236, ...	3	10	Fine clinker, .	908,900	6	0.50

OPERATION OF SEPTIC TANKS.

During the year five septic tanks have been in operation at the station.

Septic Tank A.

Septic Tank A, first put into operation during the latter part of 1897, had been in operation a little more than seven years at the end of 1904.

This is a wooden tank, having a capacity of 225 gallons, and is divided into three compartments. During the year 99,000 gallons of sewage were passed through the tank, or an average volume of 270 gallons per day. The average time of passage of sewage through the tank has varied considerably during the year. Throughout January, February and March, the theoretical time of passage was twenty-four hours; during April, May, June, July and August, twelve hours; and during September, October, November and December, thirty-six hours. Owing, however, to sludge and scum accumulations within the tank, the actual period of passage was much less than this. On the first of April the accumulation of sludge and scum within the tank was so great that the tank was emptied. This was after seven years of operation. At this time 33 per cent. of the capacity of the first compartment was filled with scum, and 48 per cent. with sludge. The second compartment was free from scum, but 67 per cent. of its capacity was filled with sludge. The third compartment was also free from scum, but 42 per cent. of its capacity was filled with sludge. After emptying, the tank was put into operation again, and on September 13, sludge had again accumulated in the tank to the extent of 22 per cent. of the capacity of the first compartment, 17 per cent. of the capacity of the second compartment and 28 per cent. of the capacity of the third compartment. This was the last measurement made during the year. The average analyses of the sewage applied to, and the effluent from, this tank follow. These analyses show that for the entire year 27 per cent. of the total organic nitrogen entering the tank did not appear in its effluent. Divided into periods the removal of organic matter was as follows: during the first period, 28.7 per cent.; during the second period, 19.6 per cent.; and during the third period, 33.9 per cent.

Sewage applied to Septic Tank A.

[Parts per 100,000.]

1904.	Temperature (Degrees F.).	Free Ammonia.	Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.			
January-March, . .	51	4.76	1.67	.95	9.73	5.87	2,939,000
April-August, . .	68	4.28	1.38	.61	13.00	4.75	1,357,000
September-December,.	58	4.24	1.62	.72	12.40	4.99	2,388,000

Septic Sewage, Tank A.

January-March, . .	52	4.60	1.19	.60	9.93	3.81	1,264,000
April-August, . .	66	4.51	1.11	.56	15.82	3.77	877,000
September-December, .	60	4.79	1.07	.62	12.55	4.07	1,627,000

Septic Tanks G and H.

In connection with the operation of Septic Tank A, two similar tanks were also operated during the year, to study further the difference in removal of organic matter from sewage by different periods of passage of sewage through septic tanks. The time of passage through Septic Tank A has been given in a previous paragraph. Through Septic Tank G, operated from the beginning of May throughout the year, the sewage was only six hours in passing; and through Septic Tank H, of the same capacity and operated throughout the same period, the sewage was eighteen hours in passing. Tables showing the average analyses of the sewage entering and of the effluent from these tanks follow; and it will be noted that, as would be expected, considerably better work was done by the tank through which the sewage was the longest time in passing. The effluent of Septic Tank G contained 64.6 per cent. of the total nitrogen in the entering sewage, and the effluent of Septic Tank H 55.4 per cent. of the total nitrogen in the entering sewage. The removal of organic matter, as shown by oxygen consumed determinations, was as follows: in Tank G, 20.8 per cent.; and in Tank H, 30.9 per cent.

Sewage applied to Septic Tank G.

[Parts per 100,000.]

1904.	Temperature (Degrees F.).	Free Ammonia.	Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.			
June-Dec., inclusive, .	63	3.94	1.61	.81	12.63	5.01	1,845,000

Septic Sewage, Tank G.

June-Dec., inclusive, .	61	3.85	1.04	.57	12.59	3.97	1,073,000

Sewage applied to Septic Tank H.

June-Dec., inclusive, .	64	3.73	1.57	.58	13.66	4.89	14,260,000

Septic Sewage, Tank H.

June-Dec., inclusive, .	62	4.05	0.87	.45	12.59	3.38	1,326,000

Septic Tank F.

This septic tank was in operation throughout the year, and to it was applied the heavy sludge resulting from allowing sewage to stand for sedimentation to take place. This sewage sludge was so applied that it was five days in passing through this tank. The average analyses of the applied sludge or sewage and the effluent of this tank follow, and show that 68 per cent. of the nitrogenous organic matter entering the tank did not appear in its effluent.

Sewage applied to Septic Tank F.

1904.	Temperature (Degrees F.).	Free Ammonia.	Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.			
February,	51	5.98	3.65	1.78	17.07	6.96	3,116,000
March,	47	5.80	2.21	0.96	8.09	6.70	3,000,000
April,	52	6.50	2.24	0.91	11.99	6.80	2,450,000
May,	63	4.93	1.71	0.66	18.02	5.42	2,830,000
June,	65	6.50	2.81	0.94	22.27	6.59	2,985,000
July,	78	4.70	0.90	0.47	21.00	5.40	550,000
August,	72	5.73	2.56	0.47	16.36	6.33	1,333,000
September,	69	5.20	1.90	0.58	22.80	5.28	1,100,000
October,	-	6.80	3.81	0.67	9.25	7.40	1,270,000
November,	55	6.65	2.49	1.07	11.85	6.59	3,525,000
December,	50	7.60	4.04	1.69	10.04	5.84	6,120,000
Average,	60	6.04	2.57	0.93	15.34	6.30	2,571,000

Septic Sewage, Tank F.

[Parts per 100,000.]

February,	58	5.56	0.89	0.55	9.96	3.03	892,000
March,	57	6.40	0.80	0.55	7.99	2.75	2,100,000
April,	59	7.05	1.27	0.79	11.64	3.90	375,000
May,	64	6.47	0.81	0.44	14.14	3.61	673,000
June,	64	6.50	0.70	0.30	18.76	2.96	300,000
July,	77	5.30	0.51	0.30	16.88	2.76	160,000
August,	72	5.97	0.87	0.41	17.19	3.23	290,000
September,	68	6.60	0.70	0.31	21.26	2.84	220,000
October,	-	6.30	0.88	0.33	9.35	2.16	640,000
November,	59	6.65	0.73	0.31	12.88	3.22	770,000
December,	55	7.60	0.94	0.41	10.06	4.04	1,150,000
Average,	63	6.40	0.83	0.43	13.65	3.14	688,000

Septic Tank D.

This tank, first put into operation during 1903, was continued during the first four months of 1904. The tank had a capacity of 300 gallons, and was divided into five compartments. It was operated at such a rate that, theoretically, the sewage was twenty-four hours in passing through each compartment, or five days in passing through the tank. A following table presents the average analysis of the entering sewage and effluent of each compartment. The results show a steady decrease of organic matter in the effluent of each compartment, the percentage removal being as follows: after passing Compartment No. 1, 1.3 per cent.; Compartment No. 2, 33.1 per cent.; Compartment No. 3, 37 per cent.; Compartment No. 4, 47.4 per cent.; and Compartment No. 5, 53.2 per cent.

Sewage for Septic Tank D.

[Parts per 100,000.]

1904.	Temperature (Degrees F.).	Free Ammonia.	Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.			
Jan.-April, inclusive, .	48	4.66	1.54	.82	11.04	5.18	2,021,000

Effluent from Compartment No. 1, Tank D.

Jan.-April, inclusive, .	46	5.93	1.52	.71	13.93	3.74	1,375,000

Effluent from Compartment No. 2, Tank D.

Jan.-March, inclusive,	46	5.48	1.03	.60	12.93	3.45	697,000

Effluent from Compartment No. 3, Tank D.

Jan.-April, inclusive, .	46	5.68	0.97	.61	11.76	3.05	908,000

Effluent from Compartment No. 4, Tank D.

Jan.-March, inclusive,	46	5.33	0.81	.49	10.66	3.01	782,000

Effluent from Compartment No. 5, Tank D.

Jan.-April, inclusive, .	46	5.30	0.72	.51	10.56	2.79	676,000

LARGE SAND FILTERS IN OPERATION AT THE STATION. — FILTERS NOS. 1 TO 10, INCLUSIVE.

For discussion of experiments in regard to oxidation in these filters, and removal of organic matter from sewage by these filters, see pages 201-216, inclusive.

Filter No. 1.

Filter No. 1 is constructed of 60 inches in depth of coarse sand of an effective size of 0.48 millimeter, and is $\frac{1}{200}$ of an acre in area. On March 24 the surface of the tank was ridged and trenched. On August 28 the surface was again disturbed, the sand levelled, and ridges and trenches again made. The surface sand in the trenches of the filter was raked 1 inch deep three times in January, twice in February, twice in December and once a week during the remainder of the year. On December 24, the trenches were covered with boards. During January, 34 inches of snow and 9¼ inches of ice were removed from the filter; during February, 17 inches of snow and 8 inches of ice; during March, 4 inches of snow; during April, 1½ inches of snow; during November, 1½ inches of snow; and during December, 6 inches of snow and 1⅛ inches of ice.

Filter No. 2.

Filter No. 2 is $\frac{1}{200}$ of an acre in area, and is constructed of 60 inches in depth of fine sand of an effective size of 0.08 millimeter, with circular trenches 1 foot wide and 2 feet deep of medium sand of an effective size of 0.19 millimeter, the surface of these trenches being below the surface of the remainder of the filter and to them the sewage is applied. The surface of the trenches was raked once each week during February, twice during March, three times during December, and once a week during the remainder of the year. On January 13, 1 inch of surface sand from the inner trench and ½ inch from the outer trench was removed and piled on the ridges. On January 15, enough sand was removed from the trenches to increase their depth two inches, and the removed sand piled on ridges. On March 9 the upper six inches of surface sand of the trenches was dug over. Upon April 21 new trenches were constructed between the old trenches, the sand excavated being piled over the old trenches, and the new trenches were filled with sand of an effective size of 0.41 millimeter. During January, 31¾ inches of snow and 14¾ inches of ice were removed; during February, 11¾ inches of snow and 13¼ inches of ice; during March, 4 inches of snow and ⅞ inch of ice; during April, 2 inches of snow; during November, 1½ inches of snow; and during December, 8⅛ inches of snow and ⅛ inch of ice.

Filter No. 4.

Filter No. 4 is $\frac{1}{200}$ of an acre in area, and is constructed of 60 inches in depth of fine river silt of an effective size of 0.04 millimeter, with two circular trenches about 14 inches wide and 12 inches deep, of coarse sand of an effective size of 0.48 millimeter. The surface of these trenches is below the remainder of the filter, and to them the sewage is applied. The trenches were raked 2 inches deep January 26, 1 inch deep during February, twice during March, once during December and once a week during the remainder of the year. On August 28 the trenches were dug over 6 inches deep. On August 29, new trenches were made between the old trenches, one trench 18 inches wide and 1 foot deep; and in the centre of the filter a cylindrical body of sand 48 inches in diameter and 1 foot deep was placed. The fine sand removed from the excavation was piled over the old trenches, and the new trenches, filled with sand of an effective size of 0.41 millimeter. During January, 31 inches of snow and 13¾ inches of ice were removed from the filter; during February, 5 inches of snow and 19½ inches of ice; during March, 1 inch of snow and 1½ inches of ice; during April, 2 inches of snow; during November, 1 inch of snow; and during December, 5¾ inches of snow and 1¼ inches of ice.

Filter No. 5B.

This filter is $\frac{1}{200}$ of an acre in area, and is constructed of 60 inches in depth of a mixture of cinders and ashes from the combustion of soft coal. It was first put into operation March 5, 1898. On November 21, the surface of this filter was trenched and ridged. The surface of the filter was raked once during January, once during February, once during December and once each week during the remainder of the year. During January, 29½ inches of snow and 5⅞ inches of ice were removed from the filter; during February, 12½ inches of snow and 9⅝ inches of ice; during March, 6¼ inches of snow; during April, 1½ inches of snow; during November, 1½ inches of snow; and during December, 8½ inches of snow.

Filter No. 6.

This filter is $\frac{1}{200}$ of an acre in area, and is 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. On March 31, the surface of the filter was levelled and the upper six inches of sand were dug over. On May 4, the surface sand was again dug over. On June 5, the filter was trenched and ridged. The surface of the filter was raked twice in January, twice in February, not at all during December and once each week during the rest of the year. During the period after June 5, sand in the trenches only was raked. During January, 34 inches of snow and 5½ inches of ice were removed; during February, 14 inches of snow and 5 inches of ice; during March, 4¼ inches of snow; during April, 1½ inches of snow; during November, 1½ inches of snow, and during December, 6 inches of snow and 2¾ inches of ice were removed.

Filter No. 9A.

This filter is $\frac{1}{200}$ of an acre in area, and is constructed of 5 feet in depth of sand of an effective size of 0.17 millimeter. Upon March 30, the surface of the filter was levelled, the sand dug over 6 inches deep and the surface trenched and ridged. Upon May 4, the surface was again levelled and the sand loosened to a depth of 6 inches. On June 5, the surface of the filter was again trenched and ridged. The surface of the filter was raked 1 inch deep three times in January, three times in February, once during December and once a week during the rest of the year; that is to say, during a portion of the year when the surface was trenched, the sand in the trenches only was raked. During January, 37½ inches of snow and 4½ inches of ice were removed from the filter; during February, 35 inches of snow and 7⅝ inches of ice; during March, 3 inches of snow; during April, 1 inch of snow; during November, 1½ inches of snow; and during December, 5½ inches of snow and ½ inch of ice.

Filter No. 10.

This filter is $\frac{1}{200}$ of an acre in area, and is constructed of 5 feet in depth of mixed fine and coarse sand of an effective size of 0.35 millimeter. No underdrains are beneath the sand, except directly above and around the outlet pipe. A partition extending 3 feet below the surface separates the quarter of the surface which is farthest from the underdrains, from the remainder of the surface. To this quarter, the sewage is applied. Over the remainder of the surface is a layer of loam 8 inches in depth. On March 30, the surface sand in that portion of the filter to which sewage is applied was dug over 6 inches deep. On August 23, 8 inches in depth of sand were removed from the portion of the surface to which sewage is applied, and piled on the remaining portion of the filter. On December 23, 1 inch in depth of sand was removed and also piled on the remaining portion of the filter. The surface was raked 1 inch deep once in February, once in December and once a week during the remainder of the year. During January, 38 inches of snow and 10¾ inches of ice were removed from the filter; during February, 19½ inches of snow and 8⅛ inches of ice; during March, 6½ inches of snow and ⅛ inch of ice; during April, 1 inch of snow; during November, 1 inch of snow; and during December, 7¾ inches of snow and 1⅜ inches of ice.

Effluent of Filter No. 1.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
January, .	56,500	51	36	12h. 44m.	Slight.	0.81	3.7960	.1296	7.73	0.74	.0018	1.23	155,900
February, .	60,000	51	36	7h. 35m.	Slight.	0.68	4.1860	.1288	7.90	0.78	.0031	1.07	178,700
March, .	60,000	49	37	41m.	Slight.	0.94	4.0625	.2170	10.28	1.47	.0073	1.31	179,900
April, . .	60,000	50	45	35m.	V. slight.	0.55	3.4125	.1120	11.31	4.00	.0125	0.75	22,500
May, . .	55,400	59	57	13m.	V. slight.	0.41	0.4200	.0440	15.82	5.99	.0012	0.49	8,400
June, . .	50,800	65	63	7m.	V. slight.	0.22	0.0640	.0440	14.50	4.62	.0006	0.39	10,800
July, . .	57,700	72	72	9m.	0.3	0.23	0.0260	.0925	15.82	4.08	.0003	0.43	6,200
August, .	51,100	71	72	3m.	0.1—	0.21	0.0196	.0392	14.74	7.66	.0002	0.38	3,167
September, .	48,500	66	69	11m.	0.1	0.22	0.1817	.0437	16.24	3.35	.0031	0.38	11,500
October, .	43,800	57	59	11m.	0.3	0.24	0.6945	.0510	9.61	2.73	.0037	0.49	11,650
November, .	60,000	55	51	9m.	0.3	0.25	1.0533	.0673	10.42	2.73	.0123	0.70	10,967
December, .	55,500	57	41	5h. 17m.	0.8	0.41	1.2667	.1000	5.19	1.92	.0075	0.80	16,967
Average, .	54,900	59	53	-	0.3	0.43	1.5986	.0891	11.63	3.34	.0045	0.70	51,388

Effluent of Filter No. 2.

January, .	29,200	52	35	24h.	V. slight.	0.48	1.6730	.0784	9.65	0.50	.0192	0.82	3,215
February, .	32,000	56	35	-	V. slight.	0.90	1.5438	.0905	8.01	0.51	.0080	1.10	3,488
March, .	26,700	48	36	7h. 39m.	V. slight.	3.45	3.4533	.2013	7.44	0.06	.0070	2.13	2,967
April, . .	23,100	49	42	2h. 9m.	V. slight.	2.48	5.2967	.1703	10.86	0.97	.0157	1.60	2,000
May, . .	35,400	60	54	8m.	V. slight.	0.63	4.2317	.0913	11.87	2.23	.0133	0.81	2,600
June, . .	33,800	65	60	9m.	V. slight.	0.38	2.8000	.0850	18.38	3.53	.0144	0.57	700
July, . .	38,500	73	70	7m.	0.1	0.34	0.6650	.0505	14.35	3.78	.0102	0.45	296
August, .	34,100	71	70	17m.	0	0.23	0.0335	.0217	16.75	4.66	.0035	0.35	1,692
September, .	32,300	66	68	10m.	0	0.20	0.0071	.0230	17.11	3.75	.0009	0.26	1,251
October, .	29,200	57	60	21m.	0.1—	0.18	0.0027	.0196	6.62	2.19	.0000	0.25	1,750
November, .	40,000	53	50	28m.	0.1	0.15	0.0950	.0251	12.83	3.81	.0048	0.37	100
December, .	37,000	54	41	3h. 4m.	0	0.17	1.1800	.0440	8.13	1.85	.0272	0.47	1,283
Average, .	32,600	59	52	-	-	0.80	1.7485	.0751	11.83	2.32	.0104	0.77	1,779

Effluent of Filter No. 4.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
January, .	13,800	63	34	23h.	0	0.07	0.0160	.0118	9.61	1.21	.0001	0.19	151
February, .	19,200	59	33	24h.	0	0.10	0.0246	.0136	10.88	1.53	.0002	0.21	119
March, .	14,800	52	35	16h. 46m.	0	0.31	0.4942	.0542	11.66	0.76	.0015	0.60	150
April, . .	20,000	49	41	1h. 30m.	0	0.31	0.5613	.0550	9.67	1.59	.0054	0.53	293
May, . .	18,500	59	54	25m.	0	0.09	0.9533	.0393	7.77	4.30	.0089	0.25	1,299
June, . .	18,500	66	61	10m.	0	0.08	0.8000	.0290	10.88	7.31	.0007	0.26	44
July, . .	20,000	72	69	13m.	0	0.11	0.3200	.0265	13.69	5.74	.0003	0.18	34
August, .	17,800	71	69	11m.	0	0.08	0.0148	.0173	15.10	4.95	.0000	0.20	800
September, .	15,400	66	65	2m.	0	0.08	0.0083	.0167	14.32	4.01	.0001	0.20	947
October, .	15,400	57	59	20m.	0	0.10	0.0024	.0123	7.58	2.58	.0000	0.18	345
November, .	20,000	53	54	7m.	0	0.07	0.0019	.0121	9.23	3.04	.0000	0.16	266
December, .	23,000	55	44	4h. 19m.	0	0.11	0.0657	.0140	10.13	4.21	.0256	0.19	600
Average, .	18,000	60	52	–	0	0.13	0.2719	.0252	10.88	3.44	.0036	0.26	417

Effluent of Filter No. 5B.

January, .	80,000	50	36	9h. 49m.	Slight.	0.69	3.5080	.1360	9.01	1.62	.0105	1.06	104,600
February, .	67,200	54	37	7h. 50m.	Slight.	0.62	2.7875	.1210	9.90	1.96	.0085	1.07	105,400
March, .	80,000	51	38	1h. 51m.	Slight.	1.05	3.4300	.1800	9.55	1.88	.0047	1.29	113,000
April, . .	76,900	50	45	32m.	Slight.	0.56	2.1500	.1095	8.69	4.36	.0100	0.83	27,500
May, . .	70,800	59	58	3m.	V. slight.	0.21	0.2900	.0447	10.93	5.29	.0007	0.42	4,900
June, . .	70,800	65	62	2m.	V. slight.	0.20	0.2750	.0460	15.64	5.54	.0002	0.39	950
July, . .	76,900	72	72	5m.	0.2	0.21	0.1000	.0850	15.34	5.69	.0006	0.41	1,600
August, .	80,000	71	72	4m.	0.1—	0.18	0.1172	.0395	15.84	5.11	.0001	0.38	7,400
September, .	61,500	66	69	5m.	0.1—	0.16	0.1184	.0378	15.83	4.62	.0001	0.32	1,500
October, .	61,500	59	59	7m.	2.8	0.29	1.2000	.1080	8.10	2.35	.0007	0.75	55,050
November, .	80,000	63	52	6m.	0.6	0.49	2.2800	.0993	13.90	2.74	.0009	0.91	18,000
December, .	65,200	58	45	47m.	1.0	0.91	2.6167	.1340	8.87	1.35	.0037	1.34	53,050
Average, .	72,600	60	54	–	0.8	0.46	1.5727	.0951	11.80	3.54	.0034	0.76	41,100

Effluent of Filter No. 6.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
January, .	58,500	56	35	7h. 19m.	V. slight.	1.24	3.7200	.1720	8.61	0.46	.0018	1.64	21,800
February, .	57,600	55	36	6h. 6m.	Slight.	1.12	4.2000	.1730	9.03	0.44	.0014	1.52	87,000
March, .	60,000	49	38	2h. 28m.	V. slight.	0.95	4.2750	.1860	9.34	0.98	.0024	1.26	41,500
April, . .	48,500	50	44	39m.	V. slight.	0.70	3.3667	.1197	9.94	2.95	.0130	0.99	25,500
May, . .	52,200	59	58	9m.	V. slight.	0.25	1.8233	.0497	14.01	7.18	.0185	0.36	4,600
June, . .	55,400	65	62	30m.	V. slight.	0.21	0.1280	.0460	16.32	4.54	.0008	0.31	2,500
July, . .	60,000	72	72	11m.	0.1—	0.19	0.0084	.0318	14.81	4.60	.0009	0.41	2,600
August, .	58,100	71	72	7m.	0	0.17	0.0069	.0244	15.35	5.20	.0002	0.34	3,100
September, .	46,200	67	68	20m.	0.1—	0.16	0.0249	.0251	12.83	4.06	.0012	0.25	2,325
October, .	43,800	62	58	17m.	0.1	0.21	0.2400	.0380	8.58	2.30	.0058	0.31	12,250
November, .	60,000	55	49	49m.	0.1—	0.31	0.5813	.0693	9.92	2.58	.0037	0.55	40,100
December, .	52,600	56	39	4h. 55m.	0.2	0.23	0.8533	.0593	4.96	1.35	.0079	0.46	14,400
Average, .	54,400	60	53	-	0.1	0.48	1.6023	.0829	11.14	3.05	.0048	0.70	21,500

Effluent of Filter No. 9A.

January, .	60,800	62	38	5h. 42m.	Slight.	0.81	3.2800	.1204	9.85	1.15	.0038	1.15	123,700
February, .	53,600	61	41	9h. 24m.	V. slight.	0.55	3.1725	.1050	9.49	1.76	.0044	0.94	19,700
March, .	60,000	59	42	1h. 26m.	V. slight.	0.60	2.0250	.0870	7.94	2.07	.0078	0.82	39,100
April, . .	46,200	62	45	31m.	0	0.29	1.7533	.0567	10.12	5.28	.0110	0.49	2,800
May, . .	52,200	60	58	8m.	V. slight.	0.22	0.1547	.0340	14.61	4.59	.0000	0.33	4,100
June, . .	55,400	65	64	16m	V. slight.	0.22	0.0180	.0370	16.57	3.53	.0000	0.38	725
July, . .	60,000	73	71	15m.	0.1—	0.20	0.0062	.0329	14.45	3.64	.0005	0.29	1,385
August, .	58,100	71	70	8m.	0	0.18	0.0091	.0317	15.19	5.80	.0001	0.31	590
September, .	48,500	66	68	46m.	0.1—	0.17	0.0803	.0327	14.13	2.52	.0003	0.35	1,975
October, .	41,500	62	59	39m.	0.1—	0.18	0.2125	.0239	9.48	1.80	.0007	0.26	233
November, .	60,000	54	52	1h. 4m.	0.1—	0.28	1.0267	.0513	9.60	2.10	.0006	0.57	1,260
December, .	48,900	61	45	7h. 12m.	1.2	0.49	1.3167	.1000	6.71	1.13	.0021	0.84	13,400
Average, .	53,800	63	54	-	0.3	0.35	1.0046	.0594	11.51	2.95	.0026	0.56	17,400

Effluent of Filter No 10.

January, .	15,400	54	43	-	V. slight.	0.58	1.7790	.0924	9.20	0.95	.0010	0.71	18,400
February, .	16,000	53	44	13h. 30m.	V slight.	0.87	3.1100	.1115	9.21	1.29	.0009	1.12	16,000
March, .	16,300	54	39	1h. 22m.	V. slight.	0.72	1.5650	.0967	4.75	0.68	.0015	1.03	19,000
April, . .	15,400	57	45	27m.	V. slight.	0.22	2.5000	.0520	11.55	3.92	.0028	0.38	3,070
May, . .	17,700	60	56	4m.	V slight.	0.18	0.2460	.0367	14.97	3.92	.0005	0.30	2,700
June, . .	18,500	65	61	2m.	V. slight.	0.18	0.0420	.0255	16.72	4.53	.0004	0.28	1,450
July, . .	20,000	72	69	2m.	0.1—	0.18	0.0077	.0307	15.47	4.74	.0002	0.28	322
August, .	20,000	71	69	8m.	0	0.17	0.0051	.0194	15.74	3.40	.0000	0.27	597
September, .	16,200	66	66	13m.	0	0.18	0.0097	.0233	14.59	2.38	.0001	0.23	602
October, .	14,600	62	60	14m.	0.1—	0.17	0.0230	.0218	9.29	2.35	.0000	0.25	730
November, .	20,000	54	53	37m.	0	0.19	0.4307	.0527	12.83	3.36	.0031	0.35	106
December, .	16,700	56	46	3h. 54m.	0.1	0.25	1.4750	.0540	7.80	1.70	.0122	0.60	1,083
Average, .	17,200	60	54	-	-	0.32	0.9328	.0514	11.84	2.77	.0019	0.48	5,338

Sand Filtration of Septic Sewage.

Filter No. 100 is $\frac{1}{20000}$ of an acre in area, and is constructed of 60 inches in depth of sand with an effective size of 0.26 millimeter. This filter was first put into operation Jan. 1, 1898, and was continued throughout 1904. It has always been flooded with the effluent of Septic Tank A. The filter is raked each week, and it was necessary on April 6 to remove 6 inches in depth of clogged sand. The table of average analyses of its effluent follows.

Filter No. 242, constructed of 48 inches in depth of sand of an effective size of 0.41 millimeter, was put into operation February 1, and received the effluent of Septic Tank D at an average rate of 100,000 gallons per acre daily. A table giving the average analysis of its effluent follows.

Effluent of Filter No. 100.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature-Deg. F.		Length of Time Sewage remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
January, .	300,000	53	54	44m.	Slight.	0.65	0.7900	.0940	9.99	3.21	.0310	0.94	63,300
February, .	300,000	50	56	1h. 25m.	Slight.	0.80	0.7500	.1140	8.83	0.80	.0038	1.23	65,000
March, .	288,900	54	58	6h.	Slight.	0.85	1.0425	.1240	8.43	0.49	.0055	1.10	23,300
April, . .	242,300	50	56	45m.	Decided.	1.60	2.3000	.2420	9.05	0.73	.0645	3.24	242,000
May, . .	288,500	64	58	1h. 2m.	Decided.	0.62	0.4100	.0860	12.03	0.72	.0064	0.89	23,800
June, . .	288,500	65	62	1h. 10m.	Decided.	0.41	0.4580	.0990	14.62	1.46	.0054	0.81	9,300
July, . .	103,800	79	72	-	2.5	0.38	5.1000	.2920	16.38	6.12	.1100	2.19	39,000
August, .	200,000	73	68	20m.	0.5	0.31	0.0945	.0470	13.65	2.01	.0040	0.44	6,250
September, .	200,000	68	66	45m.	0.1	0.16	0.2035	.0535	9.95	3.36	.0014	0.28	5,250
October, .	161,500	-	62	-	0.5	0.20	0.1160	.0540	11.75	1.63	.0008	0.33	48,500
November, .	200,000	55	50	-	1.1	-	0.2845	.0555	12.22	2.69	.0016	0.59	18,000
December, .	96,300	56	56	-	4.0	2.00	1.4250	.1320	6.15	1.10	.0360	1.74	-
Average, .	222,500	61	60	-	1.4	0.73	1.0812	.1161	11.09	2.03	.0225	1.15	49,400

Effluent of Filter No. 242.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.		
February, .	100,000	58	60	V. slight.	0.83	1.0733	.0673	43.12	0.26	.1083	.80	444,400
March, . .	100,000	57	62	V. slight.	1.08	1.3750	.0545	10.80	4.37	.1250	.52	39,800
April, . .	100,000	59	59	Slight.	1.10	0.1167	.0607	12.32	4.20	.2260	.41	75,400
May, . .	91,400	64	65	Slight.	1.00	0.1190	.0580	12.94	4.30	.3200	.72	3,300
June, . .	100,000	64	68	Slight.	0.45	0.0660	.0447	18.71	3.64	.2103	.43	4,700
July, . .	100,000	77	75	0.1	0.44	0.0640	.0380	17.31	5.20	.1300	.37	1,800
August, .	97,800	72	72	0.4	0.53	0.0750	.0260	16.20	5.06	.0067	.29	200
September, .	83,700	68	67	0.1	0.39	0.0660	.0350	16.98	4.18	.0036	.25	82
October, .	61,000	–	61	–	–	0.0740	.0280	9.80	4.48	.0032	.34	230
November, .	100,000	59	55	–	0.22	0.2040	.0360	12.33	5.12	.0075	.48	120
December, .	51,400	55	57	–	0.27	0.5500	.0520	10.02	6.38	.0030	.38	275
Average, .	89,600	63	64	0.2	0.63	0.3439	.0455	16.41	4.29	.1040	.45	51,846

OPERATION OF CONTACT FILTERS.

During the year, six contact filters have been in operation at the station, namely, Filters Nos. 103, 175, 176, 221, 237 and 251.

Filter No. 103 ($\frac{1}{20000}$ of an Acre in Area).

Filter No. 103 was a coke contact filter 5 feet in depth, the coke in this filter being of such a size that all would pass through a sieve with a $\frac{1}{2}$-inch mesh and practically none through a sieve with a $\frac{1}{8}$-inch mesh. This filter was continued in operation until June 10, 1904, and at this date it had been in operation six years and six months. This filter always received the effluent of Septic Tank A, and when first put into operation the rate was about 1,000,000 gallons per acre daily, the filter being filled once daily. This rate, owing to the usual loss of open space that takes place during the first two or three months of operation of contact filters, was decreased somewhat; and after several years of operation it was necessary to fill the open space twice daily, in order to obtain a rate approximating that maintained when the filter was started. During 1903, the average rate of operation was 788,500 gallons per acre daily. Towards the end of that year, however, the open space of the filter began to decrease with considerable rapidity. This continued throughout the first six months of 1904, and finally the clogging was so great that the filter was put out of operation. A considerable percentage of this filling of open space was due to an accumulation of organic matter, but much was due to a breaking down or disintegration of the particles of coke after this more than six years' use, with its consequent saturation. Examination of the coke after the filter was put out of operation showed that the filtering material contained 25 per cent. by weight of organic matter. This filter was constructed of ordinary gas-house coke, more or less friable. A new filter to take its place was constructed of hard Pennsylvania coke, the pieces being of practically the same size as those used in Filter No. 103. This filter was called No. 251, and will be described later.

Effluent of Filter No. 103.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
January, .	640,000	53	54	Decided	0.55	1.3900	.1920	.1130	8.62	.58	.0025	1.58	495,000
February, .	288,000	50	56	Decided.	0.90	1.6600	.2020	.1400	8.20	.03	.0012	1.66	315,000
March, . .	397,000	54	56	Great.	1.75	1.5600	.1960	.1240	7.65	.51	.0070	1.51	130,000
April, . .	589,200	50	51	Decided.	0.73	2.0800	.2500	.1260	11.08	.33	0011	1.36	408,000
May, . .	551,500	64	64	Decided.	0.80	1.3000	.1580	.1080	12.48	.02	.0013	1.11	99,800
June, . .	487,500	65	60	Great.	0.90	2.3500	.1750	.1520	19.30	.04	.0000	1.60	165,000
Average, .	492,200	56	57	Decided.	0.94	1.7233	.1955	.1272	11.22	.25	.0022	1.47	268,800

Filters Nos. 175 and 176 (Each $\frac{1}{20000}$ of an Acre in Area).

Filters Nos. 175 and 176, first put into operation June 3, 1901, were continued during 1904. Each filter is 5 feet in depth, and is constructed of pieces of coke of such size that all will pass through a sieve having a 1-inch mesh, 75 per cent. through a $\frac{1}{2}$-inch mesh and practically none through a sieve with a $\frac{1}{4}$-inch mesh. Filter No. 175 has always received sewage that has passed through a coke or coal strainer, and Filter No. 176 has received the regular station sewage. Each of these filters is allowed to rest one week in each six. During the year, Filter No. 175 was operated at the rate of 470,000 gallons per acre daily, and Filter No. 176 at the rate of 465,000 gallons per acre daily. Filter No. 175, receiving a sewage freer from matters in suspension, gave, as usual, the best purification. Tables showing the results of the analyses of the effluents of these filters follow.

Effluent of Filter No. 175.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	506,900	56	58	Decided.	.59	1.8250	.2060	.1370	7.45	2.56	.0290	2.05	990,000
February, .	524,000	55	61	Decided.	.62	0.9000	.1860	.1400	7.31	2.48	.0248	1.25	638,000
March, . .	630,000	50	59	Decided.	.78	0.9300	.2070	.1620	7.28	3.06	.0880	1.48	553,000
April, . .	453,500	51	55	Decided.	.63	1.0200	.1940	.1030	12.98	2.32	.0300	1.15	378,000
May, . .	459,400	59	65	Decided.	.58	0.8563	.2000	.1300	14.51	1.71	.0350	1.38	2,910,000
June, . .	548,500	65	62	Great.	.50	0.4600	.2000	.1150	14.75	1.97	.0040	1.40	530,000
July, . .	548,500	72	72	13.5	.83	0.2625	.2275	.1600	15.01	2.12	.0170	1.79	407,500
August, .	300,900	71	72	7.0	.70	0.6600	.2440	.1700	15.58	0.23	.0020	1.44	775,000
September, .	408,700	65	67	9.0	.60	0.6500	.2640	.1460	17.91	1.08	.0024	1.63	750,000
October, .	441,300	58	63	8.0	.55	1.1600	.2960	.1780	14.01	1.34	.0440	1.09	1,060,000
November, .	486,300	53	58	12.0	.67	1.8000	.3600	.2700	12.91	2.18	.0320	1.88	1,323,000
December, .	326,700	45	58	4.0	.50	1.3500	.1500	.1320	8.88	3.69	.0880	1.16	–
Average, .	469,600	58	63	8.9	.63	0.9895	.2279	.1536	12.38	2.06	.0330	1.48	937,700

Effluent of Filter No. 176.

January, .	531,600	53	52	Decided.	.58	0.6000	.1740	.1240	6.80	1.93	.0115	1.23	737,500
February, .	515,600	49	56	Decided.	.75	1.1000	.2680	.1300	9.23	0.04	.0013	1.84	1,050,000
March, . .	311,100	50	56	Decided.	.70	3.0000	.2340	.1190	8.00	0.03	.0002	1.64	167,500
April, . .	463,900	51	52	Decided.	.78	3.2500	.3320	.2930	11.48	1.17	.0170	1.50	1,043,000
May, . .	512,700	59	65	Decided.	.63	2.0875	.2175	.1140	13.86	0.32	.0025	1.60	270,000
June, . .	583,800	65	62	Great.	.90	1.8500	.2500	.1300	14.42	0.06	.0006	1.64	375,000
July, . .	601,600	72	72	15.0	.79	0.9450	.2450	.2020	12.72	0.61	.0023	1.96	457,500
August, .	322,600	71	72	7.0	.70	1.0400	.2080	.1780	14.14	1.43	.0800	1.47	725,000
September, .	438,100	65	68	11.0	.63	1.3500	.2460	.1850	15.81	0.02	.0004	1.72	437,500
October, .	447,900	58	63	12.0	.70	2.4000	.3350	.2680	15.29	0.02	.0030	1.20	725,000
November, .	508,700	53	55	12.5	.64	2.0500	.3500	.2700	11.93	1.48	.0095	2.07	958,000
December, .	342,200	45	58	6.0	.53	1.2000	.2000	.1440	8.11	4.09	.1100	1.53	–
Average, .	465,000	58	61	10.6	.69	1.7394	.2550	.1798	11.82	0.93	.0199	1.62	631,500

Filter No. 221.

Filter No. 221 is $\frac{1}{5000}$ of an acre in area, and is constructed of 42 inches in depth of broken stone of such a grade that all the pieces will pass through a sieve with a 1-inch mesh, 25 per cent. through a $\frac{1}{2}$-inch mesh and none through a sieve with a $\frac{1}{4}$-inch mesh. The underdrains of this filter are constructed of 6 inches in depth of cobblestones laid upon brick channels. This filter was first put into operation July 7, 1903, and during 1904 was operated at a rate of 504,500 gallons per acre daily. Nitrification within this contact filter of broken stone has been very feeble during the year, and in marked contrast to nitrification that occurs within filters of rough and porous material operated in the same manner. The analyses of the effluent of this filter follow.

Effluent of Filter No. 221.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	560,000	53	48	Great.	0.74	1.9550	.2720	.2160	7.44	.17	.0002	2.46	930,000
February, .	560,000	49	46	Great.	0.75	2.5000	.3080	.2400	7.56	.17	.0011	2.64	970,000
March, . .	560,000	50	46	Great.	1.26	1.9750	.2985	.2140	7.71	.18	.0012	2.52	645,000
April, . .	560,000	51	48	Decided.	1.30	2.8750	.2450	.2160	11.44	.04	.0000	2.04	575,000
May, . .	538,500	59	59	Great.	0.97	2.2300	.3200	.2000	12.10	.03	.0002	2.82	915,000
June, . .	560,000	65	65	Great.	1.45	2.3000	.3550	.2015	11.88	.03	.0006	3.34	350,000
July, . .	560,000	72	72	8.0	0.62	1.7125	.2425	.1600	13.32	.02	.0003	1.83	310,000
August, .	542,200	71	70	8.5	0.70	1.6125	.2625	.1850	12.00	.07	.0060	1.78	905,000
September, .	406,200	65	63	6.5	0.50	1.2160	.2040	.1590	7.91	.51	.0030	1.50	1,395,000
October, .	310,600	58	61	7.0	0.68	1.6800	.3160	.2440	10.36	.04	.0030	1.96	1,200,000
November, .	475,000	53	53	17.0	0.70	2.8500	.4500	.2910	11.55	.35	.0045	2.12	1,405,000
December, .	421,500	45	49	13.0	0.70	2.6500	.3950	.3080	9.07	.07	.0025	3.64	670,000
Average, .	504,500	58	57	10.0	0.86	2.1297	.3057	.2195	10.20	.14	.0019	2.39	856,000

Filter No. 251.

Filter No. 251, $\frac{1}{10000}$ of an acre in area, is constructed of 28 inches in depth of Pennsylvania coke, this coke being of such a size that all will pass through a sieve with a $\frac{1}{2}$-inch mesh and practically none through a $\frac{1}{8}$-inch mesh. This filter was put into operation Aug. 1, 1904, and is flooded with the effluent of Septic Tank A in three doses one hour apart. Following this, the filter stands two hours and is then drained slowly. The average analysis of the effluent of this filter follows.

Effluent of Filter No. 251.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
Aug.-Dec., inclusive, .	535,400	63	60	10.5	.58	2.9678	.2739	.1928	11.37	.23	.0090	1.98	943,000

Filter No. 237.

Filter No. 237, $\frac{1}{20000}$ of an acre in area, is constructed of clinker varying in size from $\frac{3}{4}$ of an inch to $1\frac{3}{4}$ inches in diameter. Clinkers are laid over brick underdrains, and the depth of the filter, including underdrains, is 5 feet 6 inches. The filter receives the effluent of Filter No. 221, and is flooded twice daily. The average rate of operation has been 1,000,000 gallons per acre daily. A table follows, showing the average analyses of samples of effluent collected during the morning and afternoon of each day's operation.

Effluent of Filter No. 237, A.M.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.			Nitrates.	Nitrites.		
							Total.	In Solution.					
Average, .	767,000	57	53	9.0	.69	1.0681	.2097	.1372	10.94	.72	.0063	1.49	718,500

Effluent of Filter No. 237, P.M.

Average, .	950,000	57	55	8.2	.65	1.2201	.1957	.1456	10.43	.59	.0120	1.57	552,400

INTERMITTENT-CONTINUOUS OR SPRINKLING FILTERS.

Filters Nos. 135, 136, 189, 233, 234, 235, 236, 247, 248 and 222.

During 1904, ten intermittent-continuous or sprinkling filters have been in operation. Nine of these filters are located at the experiment station, and each is $\frac{1}{20000}$ of an acre in area; and one filter, No. 222, is located at the Andover filtration area, and is $\frac{1}{200}$ of an acre in area.

Some of the filters are constructed of smooth and some of rough and porous materials. They are of varying depths and are operated at differing rates. Filters Nos. 135, 136, 247, 248 and 222 are constructed of broken stone; Filters Nos. 233, 234, 235 and 236 are constructed of clinker; and Filter No. 189 of broken brick.

Filters Nos. 135 and 136 were first put into operation during 1899, and at the end of 1904 had been in operation more than five years. Each filter is 11 feet 10 inches in depth, and is constructed of broken stone all of which will pass through a screen with a 1-inch mesh, 40 per cent. through a screen with a $\frac{1}{2}$-inch mesh and 4 per cent. through a screen with a $\frac{1}{4}$-inch mesh. The sewage is distributed over the surface of these filters, as on all other intermittent-continuous filters at the station, by means of automatic tipping basins. During the year, both of these filters have received regular station sewage, Filter No. 135 being operated at an average rate of 1,150,000 gallons per acre daily, and Filter No. 136 at an average rate of 1,938,000 gallons per acre daily. Operating at these rates, there has been comparatively little difference in the keeping or non-putrescible quality of the effluents, and nitrification has been active in both. The effluent of the filter operating at the higher rate contained, however, approximately twice as much free ammonia, somewhat more albuminoid ammonia and about two-thirds the amount of nitrates of the effluent of Filter No. 135. Each filter produced a practically non-putrescible effluent.

For further information upon the quality of effluents that can be obtained by filtration in this manner through filters of broken stone, Filters Nos. 247 and 248 were put into operation during May, 1904. Each of these filters contains the same grade of broken stone as in Filters Nos. 135 and 136. Filter No. 247 is 5 feet in depth; and Filter No. 248, 8 feet in depth. Each of these filters has been operated at a rate of about 1,000,000 gallons per acre daily. The deeper of these filters produced an effluent containing as high nitrates as in the effluent of Filter No. 136; while in the shallower filter, only 5 feet in depth, nitrification was comparatively inactive, nitrates being only about one-sixth as high as in the effluent of Filter No. 135, of twice as great a depth, but operating at practically the same rate. While both filters were intended to be operated with sewage of the same strength, Filter No. 248 received during the latter part of the year a very much stronger sewage than Filter No. 247, which caused the free and albuminoid ammonia of the effluent of this filter to be somewhat greater than the same bodies in the effluent of Filter No. 247. Neither effluent was as stable as the effluent of the deeper broken-stone filters.

The fifth filter of broken stone, namely, Filter No. 222, $\frac{1}{200}$ of an acre in area, and located at the Andover filtration area, was first put into operation July 13, 1903, and has always received Andover sewage after same has passed through a settling tank. This filter contains 8 feet in depth of broken stone, and is constructed as follows: The original cypress tank used for this filter was 6 feet in depth only, and in order to obtain a depth of 8 feet the sides of the tank were built up with large field stones to a height of 2 feet. For collecting drains, 6-inch Akron drain pipes with open joints are laid across the diameters of the filter, and these pipes extend to within 2 feet of the sides of the filter. Above and around these drain pipes are placed 13 inches of large field stones, some of which are nearly a foot in diameter and on these is placed a layer of 7 inches in depth of small field stone, and above these 54 inches of broken stone, most of the pieces of which are more than 2½ inches in diameter; and, on top of this, a layer of 22 inches of broken stone of a somewhat smaller grade.

The average rate of operation of this filter during the year has been 1,465,000 gallons per acre daily. It has been evident that this filter is constructed, especially throughout its lower portion, of too coarse a grade of material to produce good results at this high rate; and it is also evident that these underdrains of very coarse material have been unnecessary, and that a shallower depth of open underdrains would have been fully as efficient in allowing free flow of effluent and removal of the coarse sediment and in thus preventing clogging of the lower layers. During warm weather nitrification in the filter was active, but during winter weather it was low. During the winter of 1903-04, as stated in the last report, the method of applying sewage was different from that followed in the warm weather; that is, instead of application by means of tipping basins, series of pipes were placed below the surface of the filter. During the winter of 1904-05, however, the tipping basin method was followed, and the filter was covered with a roof of boards. It is of interest to note that during neither winter was there the slightest trouble from cold weather, so far as the operation of the filter and disposal of sewage is concerned.

During the months of January, February and December, 1904, the temperature of the applied sewage was 44, 42 and 47 degrees F., respectively, and the temperature of the effluent was 43, 42 and 47 degrees, respectively; that is to say, the sewage passed through this filter practically without any lowering of its temperature.

As stated previously in this chapter, four intermittent-continuous filters, constructed of clinker, were in operation at the station during the year, namely, Filters Nos. 233, 234, 235 and 236. This study was planned to show the degree of purification of sewage or stability of effluent that can be obtained by filters of this material constructed of different depths and of different grades of material. Each of these filters is $\frac{1}{20000}$ of an acre in area. Filters Nos. 233 and 234 are constructed of clinker, the pieces of which vary in diameter from $\frac{3}{4}$ of an inch to $1\frac{3}{4}$ inches. Filter No. 233 is 69 inches in depth, however, while Filter No. 234 has a depth of 46 inches only. Filters Nos. 235 and 236, each $\frac{1}{20000}$ of an acre in area, are constructed of clinker, the pieces of which vary between $\frac{1}{4}$ of an inch and $\frac{3}{4}$ of an inch in diameter. Filter No. 235 has a depth of 69 inches, while Filter No. 236 has a depth of 46 inches. Each of these filters has open brick underdrains, covered with a fine layer of coarse crushed stone, and each has been operated at the rate of 1,000,000 gallons per acre daily. The tables of analyses of the effluents of these filters follow.

Filter No. 189, $\frac{1}{20000}$ of an acre in area, was first put into operation May 14, 1902, and was discontinued April 30, 1904. This filter was constructed of pieces of broken brick about 2 inches in diameter. During its period of operation in 1904, the average rate was 1,451,000 gallons per acre daily. While nitrification was generally quite active in this filter, the organic matter remaining in its effluent was but slightly changed by passage through the filter, and hence very putrescible.

Effluent of Filter No. 135.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	TEMPERATURE. DEG. F.		APPEARANCE.		AMMONIA.			Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							ALBUMINOID.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	1,018,500	53	41	Decided.	0.90	1.2800	.3300	.1540	8.68	3.45	.0030	2.92	90,800
February, .	1,023,200	49	44	Decided.	0.68	0.5200	.2820	.1440	9.56	3.15	.0033	2.14	138,800
March, . .	1,001,000	50	44	Slight.	0.63	0.2507	.2280	.1113	8.61	3.52	.0050	1.79	62,500
April, . .	1,000,000	51	47	Slight.	0.70	0.0800	.2520	.1060	10.70	4.54	.0040	2.12	14,000
May, . .	996,200	59	61	Slight.	0.48	0.3950	.5775	.1350	17.07	6.00	.0087	3.76	16,500
June, . .	994,600	65	67	Decided.	0.72	0.9000	.4640	.1270	14.31	2.59	.0126	3.21	32,000
July, . .	1,476,900	72	71	13.0	0.50	0.5267	.3800	.0803	9.63	2.34	.0061	3.50	34,800
August, .	1,490,400	71	64	5.0	0.36	0.3575	.1290	.0720	19.70	2.94	.0032	1.19	45,800
September, .	1,430,800	65	58	6.0	0.44	0.4750	.1390	.0880	8.80	1.78	.0037	1.17	52,000
October, .	1,011,500	58	58	7.0	0.48	1.0800	.2000	.1300	10.12	1.63	.0070	1.65	315,000
November, .	1,498,500	53	49	6.0	0.46	1.7563	.1900	.1080	9.08	1.59	.0090	1.55	62,500
December, .	833,000	45	48	11.0	0.51	0.8350	.2950	.1160	7.77	1.84	.0110	2.60	62,500
Average, .	1,150,400	58	54	8.0	0.57	0.7047	.2889	.1143	11.17	2.95	.0064	2.30	77,300

Effluent of Filter No. 136.

January, .	1,798,500	53	42	Decided.	0.86	1.4300	.1660	.1270	8.40	2.10	.0047	1.84	50,500
February, .	1,924,800	49	46	Decided.	0.83	1.3500	.2935	.2130	8.68	1.88	.0090	2.27	259,000
March, . .	2,012,600	50	46	Decided.	0.99	1.5900	.2640	.1800	9.07	1.73	.0103	2.19	265,000
April, . .	2,025,400	51	49	Decided.	1.30	1.0500	.3300	.1600	7.67	2.30	.0110	3.27	115,000
May, . .	1,958,500	59	61	Decided.	0.50	0.9675	.4350	.1470	16.06	3.30	.0135	3.11	40,300
June, . .	1,857,000	65	67	Decided.	0.55	0.7675	.6800	.1640	13.80	3.69	.0060	1.54	80,000
July, . .	2,262,300	72	72	13.7	0.55	0.7467	.5000	.1493	10.44	2.46	.0073	3.79	47,800
August, .	2,414,800	71	65	7.0	0.48	1.5775	.1895	.0950	19.91	1.64	.0054	1.79	51,800
September, .	1,500,000	65	60	11.0	0.55	1.0175	.2245	.1010	11.35	1.91	.0082	2.07	46,500
October, .	1,634,600	58	58	10.0	0.57	2.1000	.2500	.2000	10.00	1.00	.0130	1.85	365,500
November, .	2,500,000	53	49	6.5	0.54	2.3125	.2395	.1450	9.15	1.23	.0120	1.71	102,300
December, .	1,370,400	45	48	15.0	0.49	1.7500	.4400	.1300	8.24	1.37	.0150	3.28	62,500
Average, .	1,938,000	58	55	10.5	0.68	1.3883	.3343	.1509	11.06	2.05	.0096	2.39	123,900

Effluent of Filter No. 247.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
May-Dec., inclusive, .	925,500	61	64	8.6	.68	2.8100	.3075	.1931	12.01	0.52	.0216	1.80	390,300

Effluent of Filter No. 248.

May-Dec., inclusive, .	963,400	61	61	10.0	.73	4.0924	.5775	.2813	11.23	2.12	.0572	2.81	409,000

Sewage Applied to Filter No. 222.

[Parts per 100,000.]

1904.	Temperature. Deg. F.	Ammonia.			Kjeldahl Nitrogen.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Albuminoid.						
		Free.	Total.	In Solution.	Total.	In Solution.			
January, . .	44	3.44	0.58	.37	1.30	0.71	3.95	3.39	2,740,000
February, . .	42	3.31	0.56	.39	1.42	1.06	3.60	3.31	1,503,000
March, . .	41	2.99	1.06	.69	2.33	1.59	3.77	3.40	1,305,000
April, . . .	43	2.50	1.76	.42	4.61	1.30	3.49	0.96	6,550,000
May, . . .	49	2.58	0.46	.32	1.26	0.87	3.97	2.51	1,757,000
June, . . .	57	3.10	0.54	.28	0.97	0.51	5.06	2.10	1,593,000
July, . . .	62	2.16	0.40	.22	0.63	0.35	4.67	1.70	585,000
August, . .	64	3.65	0.32	.25	0.69	0.44	6.38	2.45	560,000
September, . .	63	4.95	0.82	.47	1.44	0.70	6.44	3.45	1,725,000
October, . .	58	4.97	0.77	.48	1.71	0.79	6.05	3.39	2,320,000
November, . .	53	4.65	0.69	.44	1.50	0.91	5.56	3.56	2,720,000
December, . .	47	2.67	0.41	.27	0.81	0.54	3.28	2.50	1,730,000
Average, . .	52	3.41	0.70	.38	1.56	0.81	4.69	2.73	2,091,000

Effluent of Filter No. 222.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Seven Days in a Week.	TEMPERATURE. DEG. F.		APPEARANCE.		AMMONIA.			Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							ALBUMINOID.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	1,472,000	44	43	Slight.	.77	3.5000	.7860	.3596	4.43	0.05	.0032	4.16	2,818,000
February, .	1,459,000	42	42	Slight.	.69	3.1750	.8525	.3125	3.59	0.04	.0025	4.04	2,783,000
March, . .	1,455,500	41	41	Slight.	.68	2.7650	.6530	.2928	3.58	0.09	.0124	2.38	1,073,000
April, . .	1,487,700	43	43	Slight.	.51	2.0938	.2800	.2100	3.25	0.06	.0085	1.59	50,000
May, . .	1,475,700	49	50	Slight.	.38	1.9875	.2863	.1875	3.69	0.45	.0133	1.32	162,000
June, . .	1,490,400	57	58	Slight.	.49	2.3500	.4360	.1900	4.09	0.13	.0192	1.60	1,122,000
July, . .	1,486,700	62	64	2.5	.54	2.1750	.4050	.1450	6.05	0.47	.0645	1.48	424,000
August, .	1,491,900	64	67	2.8	.66	2.5275	.4083	.1600	9.06	1.28	.0598	1.97	370,000
September, .	1,482,000	63	64	2.9	.59	2.3040	.3616	.1572	7.92	2.01	.0416	2.14	435,800
October, .	1,482,600	58	59	4.3	.51	2.0292	.4193	.1500	5.69	1.91	.0290	2.08	201,700
November, .	1,315,500	53	53	5.0	.52	3.0156	.4463	.2185	6.28	0.83	.0233	1.97	493,000
December, .	1,481,400	47	47	3.0	.51	2.9250	.3450	.1863	4.81	0.42	.0173	2.01	758,000
Average, .	1,465,000	52	53	3.4	.57	2.5706	.4733	.2141	5.20	0.65	.0246	2.23	891,000

Effluent of Filter No. 233.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	TEMPERATURE. DEG. F.		APPEARANCE.		AMMONIA.			Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							ALBUMINOID.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
Average, ...	885,000	58	60	9.2	.77	2.7515	.3247	.1755	10.09	1.24	.0377	2.18	418,000

Effluent of Filter No. 234.

Average, ...	949,000	58	60	11.5	.88	3.4225	.4707	.2431	10.16	0.73	.0768	2.80	717,000

Effluent of Filter No. 235.

Average, ...	896,500	58	60	7.2	.57	1.3169	.3051	.1312	11.79	2.20	.0791	1.89	982,000

Effluent of Filter No. 236.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
Average,	908,900	58	61	11.0	.77	3.5721	.4411	.2254	11.18	0.50	.0127	2.48	637,300

Effluent of Filter No. 189.

Jan.-Apr., inclusive,	1,451,500	51	47	-	.86	3.0729	.6200	.2153	7.40	2.13	.0222	2.75	554,200

DOUBLE FILTRATION.

Filters Nos. 224, 249, 250 and 252.

During the year, four secondary filters, namely, Filters Nos. 224, 249, 250 and 252, have been in operation, and have received the effluents of filters of coarse materials.

Filter No. 224 is $\frac{1}{20000}$ of an acre in area, and is constructed of 54 inches in depth of sand of an effective size of 0.27 millimeter. This filter was put into operation Oct. 1, 1903. It receives the effluents of Filters Nos. 135 and 136 after these effluents have passed through a sedimentation basin. The average rate of filtration of this filter for the year, was 500,000 gallons per acre daily, although during a considerable portion of the year the rate was considerably greater than this. At the end of 1904, it was necessary to remove 3 inches in depth of sand. The good quality of the effluent of this filter is shown by the average analysis following.

Filters Nos. 249 and 250, $\frac{1}{20000}$ of an acre in area, were put into operation May 16, 1904, and each is constructed of 60 inches in depth of sand of an effective size of 0.41 millimeter. Each filter receives the effluents of Filters Nos. 135 and 136 after these effluents have passed through a sedimentation basin, and during the year each has operated at an average rate of approximately 700,000 gallons per acre daily. It is intended with these two filters to make a study of surface treatment. Filter No. 249 is never to be dug over to a greater depth than 3 inches, and when it fails to dispose of its prescribed dose, this 3 inches of sand is to be removed. Filter No. 250, on the other hand, will be spaded to a greater depth when necessary. With filters operated at this high rate, this deeper spading will cause sand removal to be ultimately necessary, and perhaps the amount removed may be greater than from Filter No. 249.

Filter No. 252, $\frac{1}{10000}$ of an acre in area, is constructed of 36 inches in depth of coke breeze over 6 inches in depth of brick underdrains. It receives the effluents of Filters Nos. 233, 234, 235 and 236 after passage through a sedimentation tank. The filter was put into operation Aug. 4, 1904. Its average rate of filtration was 1,150,000 gallons per acre daily; and operating at this rate it was necessary to rake the filter nine times, and to remove 1 inch in depth of coke upon October 25.

Effluent applied to Filters Nos. 224, 249 and 250.

[Parts per 100,000.]

1904.	Temperature.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
Average, . .	57	3.0	.69	1.2710	.1525	.1194	11.31	2.29	.0258	1.10	524,700

Effluent of Filter No. 224.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
Average, ...	496,100	56	55	0.1	.41	0.1451	.0585	9.90	2.66	.0044	.64	71,700

Effluent of Filter No. 249.

Average, ...	683,700	61	61	0.3	.33	0.1571	.0645	13.26	3.27	.0085	.62	54,960

Effluent of Filter No. 250.

Average, ...	694,000	61	61	0.5	.34	0.1294	.0687	13.28	3.40	.0056	.61	170,200

Effluent of Filter No. 252.

Aug.-Dec., inclusive, .	1,154,000	60	57	0.8	.40	1.9167	.0912	11.23	1.46	.1044	.74	69,500

MISCELLANEOUS FILTERS.

During the year, a number of filters other than those already described have been in operation, but the results obtained from them have not been of enough significance to warrant much discussion.

Filters Nos. 202 and 203, $\frac{1}{80000}$ of an acre in area, and constructed of 4½ feet in depth of sand of an effective size of 0.27 millimeter, were continued until the end of April, and tables showing the average analyses of the effluents for that period follow. Filter No. 202 received sewage from Septic Tank A and Filter No. 203 regular station sewage. They were both operated at the average rate of 80,000 gallons per acre daily. The object of the experiment, as stated in the last report, was to compare purification of station sewage and septic sewage in duplicate filters. The results during 1904, as during 1903, showed that the filter receiving septic sewage gave a slightly poorer effluent, although nitrification was high in both filters.

Effluent of Filter No. 202.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	TEMPERATURE. DEG. F.			AMMONIA.			NITROGEN AS			
		Sewage.	Effluent.	Color.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan.-April, inclusive, .	80,000	51	59	.21	.0388	.0203	8.60	4.58	.0019	.23	1,888

Effluent of Filter No. 203.

Jan.-April, inclusive, .	80,000	52	59	.18	.2646	.0266	10.43	5.17	.0012	.30	2,400

Filters Nos. 209, 211 and 213.

These filters, first put into operation in May, 1903, were continued until the end of April, 1904. Each filter was $\frac{1}{224000}$ of an acre in area, and was constructed of 4 feet in depth of sand of an effective size of 0.27 millimeter. Filter No. 209 was flooded with sewage from the first compartment of Septic Tank D, Filter No. 211 with sewage from the third compartment of Septic Tank D, and Filter No. 213 with sewage from the fifth compartment of Septic Tank D. (For analyses of sewage applied see page 254.) Each of these filters was operated at the rate of 100,000 gallons per acre daily, and following tables show the average analyses of the effluents. It will be seen that there was a very small difference in the degree of purification obtained in each filter.

Effluent of Filter No. 209.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
Jan.-April, inclusive, .	100,000	46	48	.35	.1858	.0517	11.01	3.71	.0158	.58	6,900

Effluent of Filter No. 211.

Jan.-April, inclusive, .	100,000	46	48	.39	.2590	.0508	11.24	4.34	.0102	.54	6,000

Effluent of Filter No. 213.

Jan.-April, inclusive, .	100,000	46	48	.44	.2198	.0500	9.92	3.61	.0074	.56	6,940

Filters Nos. 226A, 227A, 228A, 239, 240 and 241.

These small filters were operated in a continuation of the investigation discussed on pages 233–239, inclusive, of the report of the Board for 1903. Each filter was $\frac{1}{224000}$ of an acre in area. Filter No. 226A was constructed of 4½ feet in depth of sterile sand. Filter No. 227A was constructed of 5 feet in depth of unsterilized sand, but the sewage applied was sterilized by heat daily. Filter No. 228A was constructed of unsterilized sand. Filter No. 239 was constructed of 5 feet in depth of sand from the surface of Filter No. 1, Filter No. 240 of 5 feet of sterile sand, the tank also being sterilized, and Filter No. 241 was constructed of 5 feet in depth of sand from the surface of Filter No. 1.

The results from these filters, taken as a whole, were practically the same as the results obtained from the similar series of filters discussed in the last report; and, as the results from Filters Nos. 226A, 227A and 228A were practically the same as the results from Filters Nos. 226, 227 and 228, the analyses of their effluents will not be inserted here.

Two filters, Nos. 239 and 241, each constructed of surface sand from Filter No. 1, were operated as comparison experiments, the sewage applied to Filter No. 239 being fresh Lawrence Street sewage, while that applied to Filter No. 241 was the ordinary station sewage, containing a certain portion of lime. The average analyses of the effluents of these two filters follow; and it is evident that, while oxidation to the stage of nitrification did not occur to any extent in either filter, still, the removal of nitrogenous matter from the sand was greater in the filter operated with fresh sewage than in the filter operated with sewage to which lime was added, the free ammonia in the effluent of Filter No. 239 being nearly twice as great as the free ammonia in the effluent of Filter No. 241, and the same can be said in regard to the albuminoid ammonias.

Effluent of Filter No. 239.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Free.	Albuminoid.		Nitrates.	Nitrites.		
Feb.-July, inclusive,	41,900	59	61	11.2761	.6106	-	.10	.0008	3.08	440,100

Effluent of Filter No. 241.

Feb.-Dec., inclusive,	31,200	58	64	6.6183	.3866	14.01*	.04	.0039	2.43	103,400

* Average for five months.

PURIFICATION OF WOOL LIQUOR.

Filter No. 232.

This small filter, $\frac{1}{224000}$ of an acre in area, was constructed of 4½ feet in depth of sand of an effective size of 0.27 millimeter. It was flooded with the waste liquor from scouring wool after the wool had first been treated by the naphtha process for removing grease. The filter was put into operation in January, and its use continued throughout the year. Nitrification became active after a short period of operation, and finally the nitrates in the effluent were practically 20 parts per 100,000. Even with this high nitrification, however, the albuminoid ammonia was more than 5 parts per 100,000. Nitrification continued good for a number of months. At the end of this time, an attempt was made to improve the work of the filter by reducing the alkalinity of the applied waste by the addition of sulphuric acid. This was not added in sufficient amounts to make the waste acid, but nevertheless nitrification in the filter decreased rapidly soon after it began to be used. The filter is remarkable in that it is the first one operated with wool liquor at the station in which nitrification has ever occurred without the addition of sewage to the waste before filtration. The average analysis of the effluent follows, together with an average analysis of the wool waste.

Average Analysis of the Applied Liquor and Effluent of Filter No. 232.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.
					Albuminoid.					
		Sewage.	Effluent.	Free.	Total.	In Solution.		Nitrates.	Nitrites.	
Applied wool waste, . . .	-	-	-	31.93	16.07	14.45	59.25	0.31	.0000	206
Effluent, Filter No. 232, . .	12,300	64	64	2.80	6.17	-	50.80	12.24	.0074	71

FILTRATION OF WATER.

A number of water filters have been in operation during the year, and the following subjects have been studied: (1) work of the Lawrence city filter; (2) sand filtration with the addition of copper sulphate to water before filtration; (3) rapid filtration with the use of aluminum sulphate as a coagulant; (4) re-filtration through a sand filter of the effluent of the alum filter; (5) double sand filtration; and (6) germicidal effect of aluminum sulphate.

LAWRENCE CITY FILTER.

The Lawrence city filter is 2.5 acres in area. It was constructed during 1893, and dividing walls separating it into three sections were built during 1902. The following tables present the average chemical and bacterial analyses of many samples of the Merrimack River water as it flows upon the filter, and of the effluent of the filter collected at different points upon the supply system.

It will be seen by the average analyses that the filter removed 99.5 per cent. of the bacteria in the river water applied to it, and that, whereas all the samples of the applied river water contained B. coli in numbers varying in different months from 12 to 129 per cubic centimeter, only 8.0 per cent. of the one cubic centimeter samples of the effluent of the filter contained this germ, and the number decreased as the water passed through the system to its consumers. It will also be noticed that the organic matter of the river water determined as albuminoid ammonia was decreased 50 per cent. by filtration.

CHEMICAL ANALYSES.

Merrimack River.

Intake of the Lawrence City Filter.

[Parts per 100,000.]

1904.	Temperature. Degrees F.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
Average, ...	51	0.1—	.39	.0126	.0216	.0175	.32	.016	.0003	.54	1.7

Merrimack River — Concluded.

Effluent of the Lawrence City Filter.

[Parts per 100,000.]

1904.	Temperature. Degrees F.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
Average,	52	0.1—	.44	.0125	.0092	.0085	.33	.040	.0000	.37	2.1
Water from the Outlet of the Distributing Reservoir.											
Average,	52	0.1—	.38	.0068	.0093	.0081	.32	.042	.0001	.32	2.0
Water from a Tap at Lawrence City Hall.											
Average,	54	0.1—	.37	.0040	.0089	–	.34	.044	.0000	.32	2.0
Water from a Tap at Lawrence Experiment Station.											
Average,	52	0	.33	.0030	.0074	–	.32	.042	.0000	.30	2.0

Merrimack River as it flows upon Lawrence City Filter.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	10,100	25	62	100
February,	7,200	24	51	100
March,	4,000	27	23	100
April,	2,700	3	12	100
May,	3,100	4	53	100
June,	5,600	5	70	100
July,	8,000	4	125	100
August,	3,500	5	34	100
September,	19,400	4	129	100
October,	5,600	5	93	100
November,	15,600	19	110	100
December,	17,900	26	115	100
Average,	8,600	–	73	100
Total,	–	151	–	–

Effluent of Lawrence City Filter.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.
January, ...	70	99.3	25	25	4.0	48.0
February, ...	55	99.2	24	24	12.5	38.0
March, ...	33	99.2	27	27	0.0	44.5
April, ...	20	99.3	4	4	0.0	25.0
May, ...	16	99.5	4	4	0.0	25.0
June, ...	22	99.6	5	5	0.0	60.0
July, ...	11	99.9	4	4	25.0	25.0
August, ...	14	99.6	5	5	40.0	0.0
September, . . .	16	99.9	4	4	0.0	50.0
October, ...	26	99.5	5	5	0.0	20.0
November, . . .	90	99.4	19	19	10.5	36.8
December, . . .	75	99.6	25	25	4.0	28.0
Average, . . .	37	99.5	–	–	8.0	33.4
Total, . . .	–	–	151	151	–	–

Water from the Outlet of the Lawrence Reservoir.

January, ...	60	99.4	25	25	4.0	28.0
February, ...	60	99.2	24	24	4.0	50.0
March, ...	80	98.0	26	26	3.8	54.0
April, ...	48	98.2	4	4	0.0	25.0
May, ...	35	98.9	4	4	0.0	0.0
June, ...	29	99.5	5	5	0.0	0.0
July, ...	18	99.8	4	4	0.0	0.0
August, ...	23	99.4	5	5	20.0	0.0
September, . . .	22	99.9	4	4	0.0	25.0
October, ...	60	98.9	5	5	0.0	0.0
November, . . .	30	99.8	19	19	5.3	10.5
December, . . .	37	99.8	26	26	0.0	42.0
Average, . . .	42	99.2	–	–	3.1	19.5
Total, . . .	–	–	151	151	–	–

Water from a Tap at Lawrence City Hall.

[Average of Bacterial Analyses.]

1901.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.
January, ...	55	99.4	25	25	0.0	32.0
February, ...	36	99.5	24	24	8.3	38.0
March, ...	46	98.9	27	27	0.0	41.0
April, ...	57	97.9	4	4	0.0	0.0
May, ...	24	99.1	4	4	0.0	25.0
June, ...	44	99.2	5	5	0.0	0.0
July, ...	35	99.6	4	4	25.0	25.0
August, ...	135	96.2	4	4	0.0	0.0
September, ...	45	99.8	4	4	0.0	0.0
October, ...	60	98.9	5	5	0.0	20.0
November, ...	43	99.7	19	19	10.5	0.0
December, ...	65	99.6	26	26	0.0	23.0
Average, ...	55	99.0	–	–	3.6	17.0
Total, ...	–	–	151	151	–	–

Lawrence City Water from a Tap at the Experiment Station.

January, ...	45	99.5	26	26	0.0	30.8
February, ...	28	99.6	24	24	4.0	21.0
March, ...	28	99.3	27	27	0.0	52.0
April, ...	70	97.4	24	24	4.2	29.1
May, ...	30	99.0	25	25	0.0	28.0
June, ...	31	99.5	25	25	0.0	20.0
July, ...	18	99.8	25	25	8.0	12.0
August, ...	38	98.9	27	27	3.7	14.8
September, ...	24	99.9	25	25	0.0	20.0
October, ...	31	99.4	26	26	0.0	30.7
November, ...	31	99.8	25	25	0.0	8.0
December, ...	50	99.7	26	26	0.0	19.2
Average, ...	35	99.3	–	–	1.7	23.8
Total, ...	–	–	305	305	–	–

SAND FILTRATION WITH ADDITION OF COPPER SULPHATE.

Filter No. 8A.

Filter No. 8A, $\frac{1}{200}$ of an acre in area, was first put into operation during 1893. During 1904, this filter contained about 30 inches in depth of sand of an effective size of 0.23 millimeter. The average rate of operation during the year has been 3,827,000 gallons per acre daily. The filter has been scraped eighteen times, and after scraping has been filled with filtered water from below. Beginning May 17, copper sulphate was introduced into the water applied to this filter, the proportion being 1 part of copper sulphate in 1,130,000 parts of water. This treatment was followed throughout the year, the proportion of copper sulphate increasing quite steadily, until at the end of the year the amount used was 1 part in 578,000 parts of water. A following table shows the amount used throughout each month of the year. Applying the copper sulphate in this way, it remained in the water above the sand for periods varying from five hours and one-quarter to a little more than eight hours, the difference being due to the differing rate of operation of the filter, this rate varying from 4,300,000 gallons per acre daily in May to 2,800,000 gallons per acre daily in December. Besides the preliminary period for germicidal action of copper sulphate in the water, while the water remained over the sand in the filter, there was an additional period, due to the time of passage of the water through the filter, about equal to the time that the water remained above the sand. Much copper was removed during filtration, however, as shown by a following table. Another table gives the rate of operation from month to month, and the time in hours and minutes of the storage of water above the filter sand.

During the year, determinations of the number of bacteria and B. coli in the water applied to and in the effluent from this filter were made. Determinations were made also during the months of September, October, November and December of the bacteria and B. coli in the water after passing to the filter, but before reaching the surface sand. Tables showing these results follow. Studying these tables, it will be noticed that the copper sulphate lessened the number of bacteria in the water to a considerable extent before reaching the surface sand of the filter, and that the B. coli were exterminated to some extent, 98 per cent. of the samples of the water before introduction of copper sulphate, and 86.8 per cent. of the samples of water taken from the tank, showing its presence.

Studying the tables showing the bacteria and B. coli in the effluent of this filter, it will be noticed that of the 1 cubic centimeter samples examined for B. coli, 26.4 per cent., and of the 100 cubic centimeter samples examined, 46.5 per cent., showed its presence, these figures being for only the period during which copper sulphate was added. These results show a poorer B. coli efficiency during 1904 than during 1903, when copper sulphate was not used. During that year, B. coli was found in 12.6 per cent. of the 1 cubic centimeter samples and in 37.4 per cent. of the 100 cubic centimeter samples that were tested. The poorer efficiency when using copper sulphate was probably due to the destruction by this germicide of many of the bacteria in the sand which aid in the elimination of such bacteria as B. coli from the water. Tables showing all these results follow.

Canal Water. — Merrimack River Water.

[Parts per 100,000.]

1904.	Temperature. Degrees F.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.			
January,	37	V. slight.	.34	.0155	.0184	.0155	.368	.023	.0003	.55	88.4	1.7
February,	38	V. slight.	.30	.0200	.0169	.0153	.371	.025	.0002	.56	84.3	1.4
March,	36	V. slight.	.35	.0098	.0164	.0136	.356	.016	.0002	.60	106.0	1.5
April,	44	V. slight.	.35	.0014	.0188	.0100	.193	.013	.0000	.41	95.8	–
May,	54	V. slight.	.51	.0077	.0161	.0145	.168	.013	.0000	.52	82.0	1.2
June,	67	V. slight.	.47	.0128	.0218	.0172	.260	.018	.0002	.44	75.0	1.5
July,	76	0.2	.48	.0080	.0212	.0160	.204	.019	.0004	.55	55.3	1.7
August,	74	0.1	.33	.0093	.0190	.0158	.401	.016	.0006	.42	61.0	1.8
September,	63	0.1—	.48	.0136	.0219	.0189	.314	.022	.0009	.60	60.0	1.6
October,	57	0.1—	.39	.0108	.0162	.0152	.252	.019	.0004	.58	79.6	1.7
November,	44	0.1—	.35	.0136	.0200	.0170	.284	.016	.0004	.46	–	1.7
December,	35	0.3	.32	.0177	.0235	.0174	.365	.020	.0004	.67	–	1.8
Average,	52	0.1	.39	.0117	.0192	.0155	.295	.018	.0003	.53	78.7	1.6

Effluent of Filter No. 8A.

[Parts per 100,000.]

1904.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature of Effluent.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Total Albuminoid.		Nitrates.	Nitrites.			
January,	3,192,400	35	0	.25	.0050	.0078	.390	.047	.0001	.41	54.8	1.5
February,	3,049,000	34	0	.29	.0145	.0096	.395	.050	.0001	.49	47.3	1.6
March,	3,596,800	36	0	.35	.0004	.0072	.346	.032	.0000	.49	74.3	1.4
April,	3,975,500	–	–	–	–	–	–	–	–	–	73.5	–
May,	4,332,300	58	0	.35	.0004	.0104	.180	.021	.0000	.49	42.2	1.0
June,	4,071,300	66	0	.39	.0044	.0183	.263	.017	.0003	.51	42.2	1.5
July,	4,348,600	76	–	.33	.0008	.0106	.192	.029	.0000	.40	50.0	1.8
August,	4,067,000	74	0	.20	.0014	.0069	.408	.034	.0000	.31	28.0	1.8
September,	4,681,000	65	0	.30	.0013	.0116	.338	.047	.0000	.46	50.6	1.6
October,	4,164,600	55	0	.34	.0012	.0096	.275	.030	.0000	.44	67.2	1.7
November,	3,675,500	44	0	.32	.0050	.0116	.292	.025	.0000	.53	–	1.8
December,	2,772,300	35	0	.25	.0163	.0127	.344	.030	.0009	.63	–	1.9
Average,	3,827,200	53	0	.31	.0046	.0106	.311	.033	.0001	.47	53.0	1.6

Table showing Amount of Copper Sulphate applied to Water, and Time of Storage of Water above Sand in Filter No. 8A.

1904.	Actual Volume of Water Filtered Daily.	Copper Sulphate.		Rate (Gallons per Acre Daily).	Storage.	
		Parts per Million.	One Part in Parts of Water.		Hours.	Minutes.
May,	26,000	0.88	1,130,000	4,300,000	5	18
June,	20,400	1.11	900,000	4,100,000	5	34
July,	21,700	1.06	943,000	4,300,000	5	18
August,	20,300	1.17	855,000	4,100,000	5	34
September,	23,400	1.04	962,000	4,700,000	4	52
October,	20,800	1.15	870,000	4,200,000	5	26
November,	18,400	1.30	769,000	3,700,000	6	10
December,	13,900	1.73	578,000	2,800,000	8	8

	Inches.
Sand,	30
Underdrains,	6
Water above sand,	17

	Gallons.
Water above sand,	2,300
Water in sand,	2,000
Water in underdrains,	500
Water in tank,	4,800

Copper in Applied Water and Effluent of Filter No. 8A, as determined by Analyses.

Date	Source of Sample.	Copper.		$CuSO_4+5H_2O$.		Quantity Examined (Liters).	Equivalent of $CuSO_4$.
		Grains per Gallon.	Parts per 100,000.	Grains per Gallon.	Parts per 100,000.		
							Mil.
Aug. 12,	Applied water,	.00257	.00440	.01007	.01727	25	1 part in 5.80
Sept. 16,	Applied water,	.01554	.02667	.06105	.10471	18	1 part in 0.96
Oct. 26,	Applied water,	.04923	.08444	.19327	.33151	18	1 part in 0.30
Nov. 9,	Applied water,	.02915	.05000	.11444	.19630	19	1 part in 0.51
Sept. 16,	Effluent,	.00356	.00611	.01399	.02399	18	1 part in 4.10
Oct. 26,	Effluent,	.00292	.00500	.01144	.01963	18	1 part in 5.10

Merrimack River Water applied to Experimental Filters.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	3,800	18	36	100.0
February,	3,700	18	39	94.5
March,	3,500	15	13	100.0
April,	1,600	18	8	94.5
May,	2,600	23	21	100.0
June,	15,100	25	141	100.0
July,	4,400	25	102	100.0
August,	5,000	27	93	100.0
September,	13,800	24	121	100.0
October,	4,200	25	42	92.0
November,	7,800	24	67	96.0
December,	11,200	26	42	100.0
Average,	6,400	-	60	98.1
Total,	-	268	-	-

Applied Water containing Copper Sulphate.— Filter No. 8A.

September,	7,700	11	32	63.6
October,	2,300	12	14	83.5
November,	2,600	12	25	100.0
December,	2,300	10	37	100.0
Average,	3,700	-	27	86.8
Total,	-	45	-	-

Effluent of Filter No. 8A.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	NUMBER OF SAMPLES TESTED FOR B. COLI.		PER CENT. OF SAMPLES CONTAINING B. COLI.	
			1 c.c.	**100** c.c.	**1** c.c.	**100** c.c.
January,	80	98.0	-	-	-	-
February,	110	97.0	-	-	-	-
March,	150	95.7	-	-	-	-
April,	43	97.3	-	-	-	-
May,	47	98.2	13	13	15.4	46.2
June,	60	99.6	23	23	8.7	30.4
July,	30	99.3	24	24	12.5	66.7
August,	26	99.5	15	15	13.3	13.3
September,	160	98.0	11	11	18.2	45.4
October,	70	96.9	12	12	25.0	41.6
November,	140	94.6	12	12	58.3	58.3
December,	300	87.0	10	10	60.0	70.0
Average,	100	96.8	-	-	26.4	46.5
Total,	-	-	120	120	-	-

Rapid Filtration with Sulphate of Alumina as a Coagulant.

Filter No. 216.

In 1903, an experiment in filtering Merrimack River water at a high rate with the aid of sulphate of alumina as a coagulant was begun, the water after receiving the coagulant having a period of sedimentation before going to the filter. The filter used has been called Filter No. 216, and is a wooden tank 28 inches in diameter or approximately $\frac{1}{10000}$ of an acre in area, containing sand of an effective size of 0.60 millimeter. The filter was constructed as follows: About 1 inch above the bottom of the wooden tank was placed a perforated galvanized iron strainer held upon supports; above this was arranged 6 inches in depth of gravel underdrains, and above these underdrains 2.5 feet in depth of sand. Before coming to the filter, the water passed through a settling tank of such capacity that, when the filter was operating at a rate of 50,000,000 gallons per acre daily, about one hour's sedimentation was obtained. The coagulant is added as the water enters the settling basin.

During 1904, this filter was operated as a preliminary filter; that is, the water, after treatment with the coagulant, sedimentation and filtration through this filter, was passed to a plain sand filter. Filter No. 216 was operated at an average rate of 41,000,000 gallons per acre daily, the intention being to operate it as near 40,000,000 gallons per acre daily as possible. During a large part of the year, the amount of coagulant used averaged 1¼ grains per gallon of water filtered. The average bacterial efficiency by coagulation and filtration through Filter No. 216 during the year was 90.6 per cent. With greater care, finer sand in the filter, and the use of a somewhat larger amount of coagulant, etc., a much greater efficiency could have been obtained, as shown by the results given by the filter during 1903 and published in the report of the Board for that year. As stated, however, the object during 1904 was to use this filter as a preliminary filter or strainer, and to learn something in regard to its efficiency when run with a minimum amount of attention, such as it would receive in ordinary factory or mill work, and placing dependence for final bacterial efficiency upon a secondary filter. The following tables show the results of chemical and bacterial analyses of the effluent of this filter and of the water after coagulation and sedimentation before passing to the filter. The B. coli efficiency of the filter was much better, comparatively speaking, than its bacterial efficiency, B. coli being found in only 17.8 per cent. of the 1 cubic centimeter samples and in 16.6 per cent. of the 100 cubic centimeter samples examined.

Effluent of Filter No. 216.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
Average, .	40,891,000	52	.07	.12	.0110	.0076	.30	.019	.0002	.20	83.0	0.8

Applied Water.—Filter No. 216.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	1,900	18	7	66.7
February,	3,000	16	5	81.2
March,	2,400	10	1	30.0
April,	700	15	3	53.3
May,	600	17	11	100.0
June,	9,400	25	59	100.0
July,	3,400	24	170	100.0
August,	2,700	26	47	96.0
September,	8,100	25	13	96.0
October,	2,600	26	24	96.0
November,	4,900	25	16	100.0
December,	6,700	26	24	96.0
Average,	3,900	–	32	84.6
Total,	–	253	–	–

Filter No. 216.—Table showing Removal of Bacteria by Sedimentation, Filtration and Total Removal.

1904.	Average Number of Bacteria in Canal Water.	Average Number of Bacteria in Water applied to Filter No. 216.	Average Number of Bacteria in Effluent of Filter No. 216.	Per Cent. of Bacteria removed by— Coagulation and Sedimentation.	Per Cent. of Bacteria removed by— The Filter.	Per Cent. of Bacteria removed by— The System.
January,	3,800	1,900	155	50.0	92.0	95.9
February,	3,700	3,000	550	18.9	81.6	85.3
March,	3,500	2,400	350	31.4	85.4	90.0
April,	1,600	700	180	56.2	74.3	88.8
May,	2,600	600	425	77.0	28.1	83.7
June,	15,100	9,400	1,400	37.7	85.1	90.7
July,	4,400	3,400	195	22.7	94.3	95.5
August,	5,000	2,700	170	46.0	93.8	96.6
September,	13,800	8,100	850	41.4	89.4	93.9
October,	4,200	2,600	450	38.0	82.7	89.3
November,	7,800	4,900	1,100	37.2	77.5	85.9
December,	11,200	6,700	1,300	40.2	80.6	88.4
Average,	6,400	3,900	600	39.0	84.6	90.6

Effluent of Filter No. 216.

[Average of Bacterial Analyses.]

Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
		1 c.c.	**100** c.c.	**1** c.c.	**100** c.c.
600	84.6	253	253	17.8	16.6

Sulphate of Alumina as a Germicide.

In this connection, experiments were made to show the germicidal effect of sulphate of alumina, and results of one experiment are shown in a following table. In this experiment, five separate volumes of water were taken. To the first, no sulphate of alumina was added; to the second, 0.5 grain; to the third, 1 grain; to the fourth, 1.5 grains and to the fifth, 2 grains. Bacterial determinations of the numbers of bacteria present in the entire sample and in the supernatant water only were made daily. Determinations of B. coli in the entire sample and in the supernatant water only were also made. Studying the tables, it will be seen that the effect of sulphate of alumina as a germicide is plainly shown, especially with the higher amounts taken, and more clearly by its effect upon B. coli than upon the total number of bacteria present.

Table showing Germicidal Effect of Sulphate of Alumina.

Bacteria per Cubic Centimeter. — Entire Sample.

Elapsed Time.	Sulphate of Alumina, in Grains per Gallon.				
	0.	**0.5.**	**1.0.**	**1.5.**	**2.0.**
Start,	1,450	1,450	1,450	1,450	1,450
1 day,	176,400	4,900	3,200	800	1,900
2 days,	321,950	550	290	110	125
3 days,	430,000	11,200	11,400	1,050	155
5 days,	129,000	25,800	4,600	1,700	260
7 days,	7,700	3,200	40,000	5,900	75,600
9 days,	15,000	1,600	26,300	300	255
11 days,	16,500	18,500	30,500	41,400	28,200

Bacteria per Cubic Centimeter. — Supernatant Water Only.

Start,	1,450	1,450	1,450	1,450	1,450
1 day,	21,500	2,150	1,600	1,150	2,000
2 days,	35,000	370	900	33	165
3 days,	57,000	5,000	21,250	3,300	22
5 days,	24,000	3,600	35,850	7,900	650
7 days,	3,000	3,000	37,800	7,700	600
9 days,	2,200	1,000	1,500	11,500	5
11 days,	2,600	1,750	3,250	1,100	4,500

Table showing Germicidal Effect of Sulphate of Alumina — Concluded.

B. Coli per Cubic Centimeter. — Entire Sample.

Elapsed Time.	Sulphate of Alumina, in Grains per Gallon.				
	0.	**0.5.**	**1.0.**	**1.5.**	**2.0.**
Start,	36	1	–	–	–
1 day,	6	0	0	0	0
2 days,	95	11	20	0	25
3 days,	65	1	16	0	0
5 days,	20	0	0	22	0
7 days,	25	0	0	0	0
9 days,	11	35	63	40	114
11 days,	0	0	0	21	0

B. Coli per Cubic Centimeter. — Supernatant Water Only.

Start,	–	–	–	–	–
1 day,	23	0	1	3	0
2 days,	15	0	2	4	2
3 days,	16	0	1	1	1
5 days,	0	0	1	0	0
7 days,	2	1	0	0	0
9 days,	4	4	1	0	0
11 days,	0	4	2	0	0

GROWTH OF BACTERIA IN FILTERED WATER.

Various experiments have been made to determine the rapidity of growth of bacteria in the effluents of filters operating by different methods. The results of two of these experiments follow, and show clearly the exceedingly rapid growth of bacteria in the effluent of Filter No. 8 A, receiving copper sulphate, as compared with the rapidity of growth in the effluent from plain sand filtration (Filter No. 220), and filtration with the aid of aluminum sulphate as a coagulant (Filter No. 216).

Table showing the Change on Standing in the Bacterial Contents of the Effluents of Mechanical Filter No 216, Slow Sand Filter No. 220 and Filter No 8A, purifying Copper-treated Water.

Elapsed Time.	Experiment No. 160, started May 19, 1904.			Experiment No. 162, started May 31, 1904.		
	effluent of filter —			effluent of filter —		
	No. 8A.	No. 216.	No. 220.	No. 8A.	No. 216.	No. 220.
Start,	143	142	5	3	55	10
1 day,	35,000	70	370	416	16	4
2 days,	31,100	38	3,100	3,900	5	8
3 days,	24,200	82	1,098	26,700	11	27
4 days,	–	–	–	26,000	14	25
5 days,	15,500	26	2,000	–	–	–
6 days,	–	–	–	15,600	200	23
7 days,	9,800	25	300	–	–	–
8 days,	–	–	–	1,500	60	12
10 days,	–	–	–	400	37	11
13 days,	–	–	–	10,300	180	7

Double Filtration. — Filter No. 243 (Supplementary to Filter No. 216).

This filter, $\frac{1}{20000}$ of an acre in area, and containing 2½ feet in depth of sand of an effective size of 0.26 millimeter, was put into operation early in 1904, and after a preliminary period of operation with river water, in order to coat the sand grains with organic matter, bacteria, etc., — the period of so-called biological construction, — began to be operated with the effluent of Filter No. 216, and at an average rate of 6,176,000 gallons per acre daily. Tables giving the results of the chemical and bacterial analyses follow. The effluent of Filter No. 216 contained, during a period from June 15 to December 31, throughout which its effluent was applied to Filter No. 243, 677 bacteria per cubic centimeter, and the effluent of Filter No. 243 contained 50 bacteria per cubic centimeter, a reduction of 74 per cent. Removal of B. coli was little improved by Filter No. 243 above that by Filter No. 216.

Effluent of Filter No. 243.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.			
July, . .	4 303,300	74	0	.18	.0006	.0090	.18	.020	.0000	.24	61.6	0.9
August, . .	4,475,600	73	0	.16	.0030	.0083	.39	.025	.0000	.26	56.0	1.1
September, .	7,417,900	65	0.1—	.15	.0010	.0100	.35	.031	.0000	.23	52.2	1.0
October, .	6,089,000	56	0	.20	.0058	.0081	.26	.025	.0000	.43	73.2	1.3
November, .	7,065,500	44	0.1—	.22	.0110	.0102	.32	.019	.0000	.38	93.2	0.9
December, .	7,707,000	36	0.1—	.14	.0166	.0117	.35	.025	.0000	.47	–	1.5
Average, .	6,176,383	58	–	.17	.0063	.0095	.31	.024	.0000	.33	67.2	1.1

Effluent of Filter No. 243.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	**100** c.c.	**1** c.c.	**100** c.c.
July, ...	34	82.6	23	23	30.4	39.0
August, ...	70	59.0	26	26	11.5	11.5
September, . . .	33	96.1	25	25	12.0	24.0
October, ...	60	86.4	26	26	11.5	15.4
November, . . .	55	95.0	25	25	0.0	0.0
December, . . .	50	96.1	26	26	3.8	3.8
Average, . . .	50	85.9	–	–	11.5	15.6
Total, . . .	–	–	151	151	–	–

Filters Nos. 218, 219 and 220.

In July, 1903, these three filters were put into operation for the purpose of studying the chemical and bacterial quality of the effluents resulting from filtering waters of three different degrees of pollution. It is also in part an experiment in double filtration, as Filter No. 218 received from March 1 until the end of the year the effluent of the Lawrence city filter. Filters Nos. 218, 219 are each $\frac{1}{10000}$ of an acre in area, and Filter No. 220 is $\frac{1}{5000}$ of an acre in area. Each filter contains $4\frac{1}{2}$ feet in depth of sand of an effective size of 0.20 millimeter. Filter No. 218 received the effluent of the Lawrence city filter, Filter No. 219 received river water to which a certain small percentage of sewage was added, and Filter No. 220 river water. Following tables show the average results of the chemical and bacterial analyses made during the year of the water applied to and of the effluents from these filters. It will be noticed that the effluent of Filter No. 218, to which city water was applied at a rate of 2,500,000 gallons per acre daily, contained on an average only 6 bacteria per cubic centimeter; that the bacterial efficiency of the filter was 75.9 per cent.; that none of the 1 cubic centimeter samples of the effluent examined contained B. coli, and only 3.3 per cent. of the 100 cubic centimeter samples of the effluent examined contained this germ.

Filter No. 220, receiving the river water, had in its effluent 47 bacteria per cubic centimeter, removing 98.9 per cent. of the bacteria in the applied water. B. coli was found in 15.1 per cent. of the 1 cubic centimeter samples of effluent examined, and 34.2 per cent. of the 100 cubic centimeter samples.

The effluent of Filter No. 219, receiving the most polluted water of the three, namely, river water to which sewage was added, had 112 bacteria per cubic centimeter in its effluent, a removal of 99.5 per cent., the number in the applied water being 49,670 per cubic centimeter. B. coli was found in 47 per cent. of 1 cubic centimeter samples, and 66.4 per cent. of the 100 cubic centimeter samples of its effluent.

Each of the filters was operated at a rate approximating 2,500,000 gallons per acre daily. The exceedingly good character of the effluent of Filter No. 218 from a chemical point of view is noteworthy. Tables showing these results follow.

Effluent of Filter No. 218.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.			
Average, .	2,496,720	58	0	.23	.0006	.0063	.30	.041	.0003	.29	63.8	2.1

Effluent of Filter No. 218.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.
March,	6	80.0	-	-	-	-
April,	10	88.4	-	-	-	-
May,	7	65.0	-	-	-	-
June,	9	59.0	-	-	-	-
July,	10	41.0	-	-	-	-
August,	5	78.2	13	13	0.0	0.0
September,	4	83.4	13	13	0.0	0.0
October,	5	85.5	13	13	0.0	0.0
November,	3	90.0	12	12	0.0	0.0
December,	5	88.7	12	12	0.0	16.7
Average,	6	75.9	-	-	0.0	3.3
Total,	-	-	63	63	-	-

Applied Water.— Filter No 219.

[Parts per 100,000.]

1904.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Albuminoid.			Nitrates.	Nitrites.			
						Total.	In Solution.						
Average,	-	54	0.2	.41	.0475	.0296	.0211	.39	.020	.0005	.57	76.4	1.7

Effluent of Filter No. 219.

Average,	2,360,200	55	0	.30	.0027	.0103	-	.35	.033	.0010	.43	30.3	1.6

Applied Water.— Filter No. 219.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
March,	42,000	-	-	-
April,	27,500	-	-	-
May,	71,400	-	-	-
June,	163,900	-	-	-
July,	37,600	-	-	-
August,	31,800	11	1,223	91.0
September,	18,000	8	469	87.5
October,	29,500	12	546	92.0
November,	51,000	7	1,217	86.0
December,	14,000	1	33	100.0
Average,	48,670	-	698	91.3
Total,	-	39	-	-

Effluent of Filter No. 219.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.
March,	120	99.7	–	–	–	–
April,	28	99.9	–	–	–	–
May,	41	99.9	–	–	–	–
June,	140	99.9	–	–	–	–
July,	65	99.8	–	–	–	–
August,	51	99.8	11	11	54.5	54.5
September,	120	99.3	8	8	62.5	75.0
October,	20	99.9	12	12	8.3	50.0
November,	210	99.6	7	7	43.0	86.0
December,	325	97.1	3	3	66.7	66.7
Average,	112	99.5	–	–	47.0	66.4
Total,	–	–	41	41	–	–

Effluent of Filter No. 220.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.			
Average,	2,391,200	54	0	.31	.0032	.0103	.30	.028	.0002	.43	41.2	1.7

Effluent of Filter No. 220.

[Average of Bacterial Analyses.]

1904.	Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.
January,	40	99.0	–	–	–	–
February,	37	99.0	–	–	–	–
March,	40	99.0	–	–	–	–
April,	28	98.3	–	–	–	–
May,	51	98.0	–	–	–	–
June,	12	99.9	–	–	–	–
July,	24	98.9	–	–	–	–
August,	26	99.5	13	13	15.4	0.0
September,	51	99.6	12	12	16.7	33.3
October,	11	99.8	13	13	0.0	30.8
November,	46	99.4	10	10	10.0	40.0
December,	200	97.0	6	6	33.3	66.7
Average,	47	98.9	–	–	15.1	34.2
Total,	–	–	54	54	–	–

Filters Nos. 245 and 246.

These two filters are each $\frac{1}{20000}$ of an acre in area, and were put into operation in April, 1904, the object of the experiment being to study filtration through sand, comparing it with filtration through sand upon which was a layer of coke. Filter No. 245 contained 4 feet in depth of sand of an effective size of 0.30 millimeter, and Filter No. 246 3 feet 8 inches in depth of sand of the same effective size, on which were 4 inches of coke breeze from which the dust had been removed, making the grains of coke approximately the same size as the sand grains. The rate of operation of these filters was slightly more than 6,000,000 gallons per acre daily. Tables showing the chemical and bacterial analyses of their effluents follow. Little difference in the character of these effluents can be noted; if anything, the sand filter proved the more efficient. The only difference in operation was that Filter No. 246 containing the coke was operated for nearly five months before surface treatment became necessary. After this, however, removal of the coke from the surface had to be made five times before the end of the year. The sand filter was scraped seven times during this period.

Effluent of Filter No. 245.

[Parts per 100 000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	APPEARANCE.		AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.			
Average,	6,295,200	59	0	.32	.0045	.0113	.29	.026	.0004	.48	45.4	1.7

Effluent of Filter No. 245.

[Average of Bacterial Analyses.]

Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	NUMBER OF SAMPLES TESTED FOR B. COLI.		PER CENT. OF SAMPLES CONTAINING B. COLI.	
		1 c.c.	**100** c.c.	**1** c.c.	**100** c.c.
300	87.8	127	125	25.7	49.9

Effluent of Filter No. 246.

[Parts per 100,000.]

1904.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.			
Average, .	6,164,100	59	0	.32	.0042	.0111	.27	.024	.0007	.48	41.8	1.7

Effluent of Filter No. 246.

[Average of Bacterial Analyses.]

Average Number of Bacteria per c.c.	Per Cent. removed (Efficiency).	Number of Samples tested for B. Coli.		Per Cent. of Samples containing B. Coli.	
		1 c.c.	100 c.c.	1 c.c.	100 c.c.
430	95.9	130	128	32.2	43.5

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The work of food and drug inspection, which has been conducted continuously by the Board since 1883, has undoubtedly secured to the people of the State a degree of protection from fraudulent and harmful adulteration which, as measured by an economic standard, is greatly in excess of the cost of administering the laws providing for this important work.

The scope of these laws is fully set forth in the report of the Board for the year 1903.

In the accompanying report of the analyst will be found a detailed account of the examination of samples of food and drugs purchased by the inspectors during the year.

The Board is required, under the provisions of the statutes, to report annually to the General Court the number of prosecutions made, and an itemized account of the money expended in carrying out the provisions of the law. (Chapter 75, section 7, Revised Laws.) This report has been made annually to the General Court in January since 1884.

A general summary of the work of the Board in this direction is also presented in the annual report of each year.

In addition to the foregoing, the Board is required by a recent statute (Acts of 1902, chapter 272) to publish as often " as once each month in the official publication of the board, . . . a certificate of the examination or analysis made by authority of the board during the preceding month of any article of food manufactured or offered for sale in the Commonwealth, which is adulterated within the meaning of chapter seventy-five of the Revised Laws; and the board shall also cause to be published, with such certificate of examination, a statement of the trade-mark, brand-mark, or name, with the name and place of business of the manufacturer, which appear upon the package or box containing such adulterated article, or with the name and place of business of the wholesale dealer of whom the goods were obtained."

The official publication referred to in the foregoing statute is the weekly bulletin of the Board, which has been published continuously during the past twenty years, and distributed principally to the health authorities of the cities and towns.

The recent law of 1902 (chapter 230) authorizes the Board " to publish for general distribution such parts of its annual report, and such other matter as it may deem adapted to promote the interests of the public in this Commonwealth." Under this provision, that portion of the report relating to food and drug inspection has since been published and distributed in pamphlet form.

The following lists contain the names of cities and towns to which warning notices of sales of adulterated food and drugs were sent in 1904, with the number of such sales in each instance: —

Cities and Towns to which Notices were sent on Account of Adulterated Milk in 1904.

Attleborough,	6	Natick,	2
Beverly,	3	New Bedford,	7
Boston,	3	Newburyport,	2
Brockton,	14	Newton,	12
Brookline,	2	North Adams,	1
Cambridge,	23	Paxton,	2
Chelsea,	21	Pittsfield,	7
Dover,	3	Plymouth,	4
Everett,	8	Provincetown,	7
Fall River,	16	Revere,	6
Fitchburg,	14	Salem,	8
Framingham,	2	Salisbury,	3
Gloucester,	33	Shrewsbury,	2
Haverhill,	5	Somerville,	10
Holliston,	1	Stoughton,	2
Holyoke,	8	Swansea,	3
Hyde Park,	1	Taunton,	1
Lawrence,	8	Waltham,	9
Lowell,	57	Wareham,	2
Malden,	3	Watertown,	6
Marblehead,	1	Wayland,	1
Marlborough,	1	Westfield,	1
Marshfield,	1	Winthrop,	2
Medford,	6	Woburn,	6
Medway,	1	Worcester,	28
Milford,	4		
Nantucket,	1	Total,	380

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food Other than Milk.

Arlington,	1	Gloucester,	3
Attleborough,	1	Holyoke,	1
Beverly,	1	Lawrence,	11
Boston,	44	Lowell,	9
Brookline,	1	Lynn,	1
Cambridge,	12	Malden,	2
Chelsea,	1	Medford,	3
Fall River,	2	Natick,	2

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food Other than Milk — Concluded.

New Bedford,	1
Newburyport,	4
Pittsfield,	7
Quincy,	1
Reading,	1
Revere,	1
Rockland,	1
Salisbury,	1
Somerville,	9
Springfield,	3
Walpole,	1
Waltham,	1
Wareham,	1
Wilmington,	1
Winthrop,	1
Woburn,	2
Worcester,	1
Total,	132

Cities and Towns to which Notices were sent on Account of Adulterated Drugs.

Andover,	2
Boston,	34
Braintree,	1
Cambridge,	4
Chelsea,	2
Everett,	1
Fall River,	4
Gardner,	1
Gloucester,	1
Holyoke,	1
Lawrence,	5
Lowell,	1
Malden,	4
Marblehead,	1
Marlborough,	1
Nantucket,	1
Natick,	1
Newburyport,	1
North Adams,	1
Northampton,	1
Palmer,	2
Pittsfield,	5
Provincetown,	1
Reading,	1
Rockland,	2
Somerville,	5
Waltham,	1
Woburn,	3
Total,	88

The following report treats of the operations of the Board under the provisions of the food and drug acts during the year ended Sept. 30, 1904. The report made to the Legislature in January, 1905, "of the number of prosecutions made under the act and an itemized account of the money expended in carrying out the provisions thereof," is also embodied in this annual report.

The following persons comprised the force employed by the Board during the year in this department: —

ALBERT E. LEACH,	*Analyst.*
CHARLES A. GOESSMANN,	*Analyst.*
HERMANN C. LYTHGOE,	*Assistant Analyst.*
JOHN F. MCCAFFREY,	*Inspector.*
JOHN H. TERRY,	*Inspector.*
HORACE F. DAVIS,	*Inspector.*

The number of samples of food and drugs examined during the year is shown in the accompanying table, together with a summary of the work done since the beginning of this line of work in 1883 :—

FOOD AND DRUG INSPECTION (1883–1904).

SUMMARY.	YEARS.	
	1904.	Total **1883-1904.**
Number of samples of milk examined,	4,997	87,304
Number of samples above standard,	3,307	55,593
Number of samples below standard,	1,690	31,711
Percentage of adulteration,	33.8	36.3
Number of samples of other kinds of food examined (not milk).	2,799	54,809
Number of samples of good quality,	2,521	44,869
Number of samples adulterated, as defined by the statutes,	278	9,940
Percentage of adulteration,	9.9	18.1
Number of samples of drugs examined,	855	15,243
Number of samples of good quality,	526	9,308
Number of samples adulterated, as defined by the statutes,	329	5,935
Percentage of adulteration,	38.5	38.9
Total examinations of food and drugs,	8,651	157,356
Total examinations of good quality,	6,354	109,770
Total examinations not conforming to the statutes,	2,297	47,586
Percentage of adulteration,	26.6	30.2
Expense of collection, examination and prosecution,	$12,069 11	$220,770 06
Expense of collection, examination and prosecution, per sample,	1 40	1 40

It appears from the foregoing table that 8,651 samples of food and drugs were collected and examined during the year ended Sept. 30, 1904, of which number 2,297, or 26.6 per cent., were found to be adulterated, or not up to the standard required by the statutes. This large ratio, however, does not represent the actual proportion of adulteration which actually exists in the general food supply. On the contrary, it far exceeds it, since the articles collected for examination are chiefly those which experience has shown to be specially liable to adulteration.

The whole number of samples of food and drugs examined since the beginning of work in 1883 was 157,356, of which 87,304, or more than one-half, as required by the statutes, were samples of milk.

The amount expended in the enforcement of the food and drug acts since the beginning of work has been $220,770.06, and the expense per sample $1.40 for the whole time. This expense was reduced from $2.26 per sample in 1883 to $1.40 in 1904.

The total amount of fines imposed for violation of the acts relating to food and drug inspection, up to Sept. 30, 1904, was $42,428.48.

PROSECUTIONS.

The following table presents the statistics relative to the prosecutions which have been conducted under the food and drug acts since the beginning of work in 1883 (Revised Laws, chapter 75, sections 16 to 27)* : —

Number of Complaints entered in Court.

YEAR.	Food and Other Articles (not including Milk).	Drugs.	Milk.	Total.	Convictions.	Fines imposed.
1883,	–	5	4	9	8	–†
1884,	2	1	45	48	44	–†
1885,‡	50	1	68	119	103	–†
1886,§	10	–	10	20	19	–†
1887,	30	–	34	64	60	–†
1888,	22	–	43	65	61	$2,042 00
1889,	74	–	66	140	124	3,889 00
1890,	78	–	24	102	96	3,919 00
1891,	96	5	49	150	135	2,668 00
1892,	52	12	72	136	123	3,661 70
1893,	26	3	67	96	92	2,476 00
1894,	14	–	76	90	77	2,625 00
1895,	13	11	68	92	86	2,895 30
1896,	7	–	68	75	74	2,812 20
1897,	13	1	51	65	64	2,756 60
1898,	10	–	54	64	62	2,060 98
1899,	19	2	26	47	45	1,432 66
1900,	45	5	44	94	89	1,890 70
1901,	30	–	65	95	90	1,874 70
1902,	25	3	48	76	74	2,617 98
1903,	34	1	44	79	70	1,297 66
1904,	6	6	50	62	57	1,509 00
	656	56	1,076	1,788	1,653	$42,428 48

Ratio of convictions to complaints, 92.4 per cent.

NOTE — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

The number of prosecutions made against offenders during the year was 62, and the number of convictions 57.

The following report was transmitted to the Legislature Jan. 21, 1905, in compliance with the terms of the statute, section 7, chapter 75, Revised Laws : —

OFFICE OF THE STATE BOARD OF HEALTH,
STATE HOUSE, BOSTON, Jan. 21, 1905.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts.

Section 7 of chapter 75 of the Revised Laws of Massachusetts provides that the State Board of Health "shall annually report to the general court the number of prosecutions made under the provisions of sections sixteen to twenty-seven, inclusive, and an itemized account of the money expended in carrying out the provisions thereof;" and in accordance with this provision the following report is made.

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* These sections have been published, together with all the other statutes relating to food and drug inspection, in a pamphlet authorized by chapter 230 of the Acts of 1902.

† No record kept. ‡ To May 1, 1886. § Four months only.

The number of prosecutions entered during the twelve months ending Sept. 30, 1904, was 62. One of the defendants left the State, pending a hearing; 1 was acquitted; 3 were discharged on motion of the prosecution, new complaints being entered against those more directly responsible; and the remainder (57) were convicted.

The following table sets forth the nature of the offence complained of, the place where the offence was committed, the date of trial and the result in each case: —

For Sale of Milk not of Good Standard Quality.

Place.	Date.	Result.
Lowell,	Oct. 14, 1903,	Conviction.
Spencer,	Oct. 21, 1903,	Conviction.
Salem,	Oct. 27, 1903,	Conviction.
Salem,	Nov. 3, 1903,	Conviction.
Salem,	Nov. 3, 1903,	*Nol pros.*
Brockton,	Nov. 5, 1903,	Conviction.
Lowell,	Nov. 28, 1903,	Conviction.
Whitman,	Dec. 16, 1903,	Conviction.
Needham,	Dec. 21, 1903,	Conviction.
Watertown,	March 12, 1904,	Conviction.
Dover,	April 27, 1904,	Conviction.
Sudbury,	April 28, 1904,	Conviction.
Sudbury,	April 28, 1904,	Conviction.
East Brookfield,	April 29, 1904,	Conviction.
Boylston,	May 3, 1904,	Conviction.
Millis,	May 24, 1904,	Conviction.
Medway,	May 24, 1904,	Conviction.
Medway,	May 24, 1904,	Conviction.
Medway,	May 24, 1904,	Conviction.
North Brookfield,	May 26, 1904,	Conviction.
New Braintree,	May 26, 1904,	Conviction.
Hampden,	May 26, 1904,	Conviction.
Hingham,	May 27, 1904,	Conviction.
Hingham,	May 27, 1904,	Conviction.
Woburn,	June 4, 1904,	Conviction.
Nantucket,	July 7, 1904,	Acquittal.
Holden,	July 28, 1904,	Conviction.
Holliston,	Aug. 6, 1904,	Conviction.
Medway,	Aug. 13, 1904,	Conviction.
Medway,	Aug. 13, 1904,	Conviction.
Carlisle,	Aug. 20, 1904,	Conviction.
Lowell,	Aug. 31, 1904,	Conviction.

Place.	Date.	Result.
Lowell,	Aug. 31, 1904,	Conviction.
Lowell,	Aug. 31, 1904,	Conviction.
Lowell,	Aug. 31, 1904,	Conviction.
South Framingham,	Sept. 3, 1904,	Conviction.
Carlisle,	Sept. 14, 1904,	Conviction.
Lowell,	Sept. 15, 1904,	Conviction.
Brookfield,	Sept. 15, 1904,	Defendant left State.
Reading,	Sept. 20, 1904,	Conviction.
Reading,	Sept. 20, 1904,	Conviction.
Salisbury,	Sept. 28, 1904,	Conviction.

For Sale of Milk containing Coloring Matter.

Salem,	Oct. 27, 1903,	Conviction.
Salem,	Nov. 3, 1903,	Conviction.
Salem,	Nov. 3, 1903,	*Nol pros.*
Gloucester,	Dec. 9, 1903,	Conviction.
Lowell,	Aug. 31, 1904,	Conviction.

For Sale of Milk containing Formaldehyde.

Lowell,	Aug. 31, 1904,	Conviction.

For dealing in Milk, Wagon bearing no Name.

Lowell,	Aug. 31, 1904,	Conviction.
Lowell,	Aug. 31, 1904,	Conviction.

For Sale of Adulterated Cheese.

Boston,	Oct. 2, 1903,	Conviction.
Boston,	Oct. 2, 1903,	Conviction.

For Sale of Adulterated Foods Other than Milk and Milk Products.

Article.	Place.	Date.	Result.
Raspberry jam,	Lowell,	Oct. 6, 1903,	Conviction.
Meat,	Boston,	March 15, 1904,	Conviction.
Cream of tartar,	Springfield,	June 17, 1904,	Conviction.
Maple sugar,	Lowell,	June 30, 1904,	Conviction.

For Sale of Adulterated Drugs.

Phenacetine,	Boston,	Oct. 30, 1903,	Conviction.
Tincture of iodine,	Newburyport,	Oct. 31, 1903,	Conviction.
Distilled water,	Newburyport,	Oct. 31, 1903,	Conviction.
Phenacetine,	Boston,	Nov. 24, 1903,	Conviction.
Tincture of iodine,	Boston,	Dec. 18, 1903,	*Nol pros.*
Phenacetine,	Boston,	Jan. 6, 1904,	Conviction.

The amount paid in fines was $1,509.

The expenditures for the year were as follows: —

Salaries of analysts,	$5,000 00
Salaries of inspectors,	4,280 00
Travelling expenses and purchase of samples,	1,935 13
Apparatus and chemicals,	452 68
Printing,	39 02
Services (cleaning laboratory),	106 00
Express and postage,	10 33
Sundry laboratory supplies,	98 25
Books and maps,	97 30
Extra services (stenographer),	29 15
Typewriting supplies,	21 25
Total,	$12,069 11

REPORT OF THE ANALYST.

By Albert E. Leach.

REPORT OF THE ANALYST.

By Albert E. Leach.

Dr. Charles Harrington, *Secretary State Board of Health.*

Dear Sir: — I herewith submit my report on the analysis of food and drugs for the year ending Sept. 30, 1904.

In the past reports, especially from 1899 on, methods of analysis of various foods examined by this department have been outlined whenever these methods are in any way peculiar to this laboratory. It should again be stated that the percentage of adulteration of the various foods and drugs as given in the statistics which follow is far higher than that of the foods as they exist on the market. This is true because in most cases only such varieties of food as are found by experience most liable to adulteration are examined; and, again, the samples of these foods collected by the inspector are in many cases of suspicious character as regards purity, discrimination being exercised in this regard by the inspector.

While in most cases usage or experience suggests the forms of adulteration peculiar to various foods, the analyst has to be on the lookout to meet new conditions constantly arising. His methods are largely qualitative, since technically he need only show, in most cases, the mere presence of a forbidden ingredient.

As a rule, a full analysis of adulterated food, beyond establishing the nature and in some instances the amount of the adulteration, is entirely unnecessary.

On account of the necessity of verifying such formulas as, under the law, must be placed on certain compound articles of food, it is frequently necessary to make quantitative determinations. When such quantitative results are calculated from assumed or variable factors, which is necessary when the adulterant or substance is itself complex or variable in composition, as, for example, in the case of commercial glucose, the analyst is always conservative in his figures, by expressing the minimum amount of the adulterant, so as to give the defendant the benefit of any doubt. The same is true where the result of the judgment is based on the appearance of the food under the microscope.

These cases should, however, be distinguished from those in which fixed and definite standards are specified by statute, as, for example, in the case of total solids or fat in milk, or acidity in vinegar. Here there is, of course, great necessity for precision in quantitative work.

MILK.

There were 4,691 samples of milk examined, of which 1,627, or 34.7 per cent. were below the standard. This high ratio of adulteration is presumably much greater than the actual conditions prevailing throughout the State, since with milk, more than in the case of other foods, the samples collected are very frequently from suspected sources.

The following tables show in summarized form the localities from which milk has been collected during the year, as well as the general quality of the milk: —

Milk from Cities.

CITIES.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with —			Number of Samples preserved with Formaldehyde.
							Annatto.	Aniline Orange.	Caramel.	
Boston, . . .	217	68	285	24.8	10.08	-	-	-	-	-
Brockton, . . .	49	37	86	43.0	10.73	1	-	-	-	-
Cambridge, . .	132	68	200	34.0	11.00	-	-	-	-	-
Chelsea, . . .	113	90	203	44.3	10.45	-	-	-	-	-
Everett, . . .	26	24	50	48.0	11.27	-	-	-	-	-
Fall River, . . .	87	42	129	32.5	9.40	-	-	-	-	5
Fitchburg, . . .	43	19	62	31.7	8.47	4	-	-	-	-
Gloucester, . .	120	92	212	43.4	8.40	-	13	-	-	1
Haverhill, . . .	39	21	60	35.0	9.53	1	-	-	-	-
Lawrence, . . .	19	5	24	20.8	10.87	-	-	-	-	-
Lowell, . . .	153	128	281	45.6	8.38	-	-	5	1	3
Malden, . . .	39	41	80	50.1	11.00	-	-	-	-	-
Marlborough, . .	59	12	71	16.9	11.84	-	-	-	-	-
Medford, . . .	32	15	47	32.0	11.52	-	-	-	-	-
North Adams, . .	10	11	21	52.4	11.16	-	-	-	-	-
New Bedford, . .	17	13	30	43.3	10.46	-	-	-	-	-
Newburyport, . .	89	16	105	15.2	11.20	-	-	-	-	-
Newton, . . .	69	55	124	44.4	10.12	-	-	-	-	2
Pittsfield, . . .	33	10	43	23.2	11.11	-	-	-	-	1
Quincy, . . .	35	5	40	12.5	11.20	-	-	-	-	-
Salem, . . .	88	28	116	24.1	9.67	-	-	-	-	1
Somerville, . . .	92	72	164	45.8	10.80	-	-	-	-	-
Taunton, . . .	66	5	71	7.6	10.10	1	-	-	-	-
Waltham, . . .	128	45	173	26.0	10.05	-	-	-	-	-
Woburn, . . .	6	19	25	76.0	9.93	-	-	-	-	-
Worcester, . . .	187	108	295	36.6	8.90	4	-	-	-	-
Summary, . .	1,948	1,049	2,997	35.0	8.38	11	13	5	1	13

Milk from Towns.

Towns.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with Aniline Orange.	Number of Samples preserved with Formaldehyde.
Adams,	11	1	12	8.3	12.97	–	–	–
Andover,	7	8	15	53.4	12.66	–	–	–
Attleborough,	91	36	127	38.4	10.00	2	–	–
Bedford,	17	3	20	15.0	11.34	–	–	–
Beverly,	14	2	16	12.5	10.92	–	–	1
Brookline,	98	30	128	23.4	11.49	–	–	–
Clinton,	9	1	10	10.0	9.86	1	–	–
Cottage City,	16	1	17	5.9	11.84	–	–	–
Dedham,	33	7	40	17.5	11.75	–	–	–
Greenfield,	15	–	15	0.0	10.04*	1	–	–
Hyde Park,	59	19	78	38.0	11.20	–	–	–
Marblehead,	13	4	17	23.5	11.60	–	–	1
Milford,	87	22	109	20.1	10.20	1	–	–
Nantucket,	15	–	15	0.0	12.00	–	–	–
Natick,	84	10	94	10.6	9.40	7	–	–
Palmer,	3	7	10	70.0	11.31	–	–	–
Plymouth,	20	3	23	13.0	12.40	–	–	–
Provincetown,	38	2	40	5.0	11.50	–	–	–
Reading,	4	6	10	60.0	10.60	–	–	–
Revere,	48	59	107	55.1	10.86	–	–	–
Rockland,	14	1	15	6.7	11.50	–	4	4
Salisbury,	31	10	41	24.4	10.00	–	–	–
Stoughton,	7	7	14	50.0	12.60	–	–	–
Wareham,	26	2	28	7.2	11.30	–	–	–
Watertown,	39	40	79	50.6	10.67	–	–	–
Westborough,	13	–	13	0.0	12.60	–	–	–
Weymouth,	10	9	19	47.3	11.00	–	–	–
Whitman,	26	8	34	23.5	9.25	–	–	–
Winthrop,	21	16	37	70.2	11.48	–	–	–
Summary,	869	314	1,183	26.5	9.25	12	4	6

* Skimmed milk, sold as such, of standard quality.

Milk from Suspected Producers.

LOCALITY.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.
Ashland,	5	6	11	83.3	11.16
Boylston,	–	3	3	100.0	8.54
Brookfield,	2	20	22	90.9	10.24
Canton,	2	18	20	90.0	10.76
Carlisle,	13	7	20	35.0	10.95
Charlton,	–	5	5	100.0	10.63
Concord,	–	19	19	100.0	11.31
Dover,	13	7	20	35.0	11.03
Framingham,	21	11	32	34.4	8.76
Hampden,	2	2	4	50.0	11.36
Hardwick,	–	5	5	100.0	10.50
Holden,	–	4	4	100.0	9.18
Holliston,	13	8	21	38.1	10.46
Medway,	37	30	67	44.7	10.53
Millis,	23	7	30	23.3	10.37
Paxton,	8	4	12	33.3	11.73
Shrewsbury,	12	8	20	40.0	11.32
Sudbury,	10	25	35	71.5	10.00
Swansea,	15	3	18	16.7	10.32
Warren,	7	3	10	30.0	11.52
Wayland,	15	–	15	0.0	12.40
Weston,	5	–	5	0.0	12.23
Woburn,	–	5	5	100.0	10.49
Summary,	203	200	403	49.8	8.54

Summary of Milk Statistics.

	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	NUMBER OF SAMPLES COLORED WITH —			Number of Samples preserved with Formaldehyde.
							Annatto.	Aniline Orange.	Caramel.	
Cities,	1,948	1,049	2,997	35.0	8.38	11	13	5	1	13
Towns,	869	314	1,183	26.5	9.25	12	–	4	–	6
Suspected producers,	203	200	403	49.8	8.54	–	–	–	–	–
Miscellaneous,	44	64	108	59.2	8.58	–	–	–	–	1
Summary,	3,064	1,627	4,691	34.7	8.38	23	13	9	1	20

The following table is inserted, showing the quality of the milk by months: —

Quality of Milk by Months.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Number having more than 15 per cent. of total solids,	26	6	18	7	10	13	15	14	18	14	11	25	177
Number having between 14 and 15 per cent. of total solids,	42	25	41	12	17	47	14	22	29	16	20	43	328
Number having between 13 and 14 per cent. of total solids,	158	63	141	57	52	138	88	108	117	60	66	150	1,198
Number having between 12 and 13 per cent. of total solids,	254	124	94	83	77	267	202	193	207	185	194	368	2,248
Number having between 11 and 12 per cent. of total solids,	26	17	13	11	9	49	71	84	57	58	66	70	531
Number having between 10 and 11 per cent. of total solids,	11	7	10	2	2	15	18	27	11	7	22	23	155
Number having between 9 and 10 per cent. of total solids,	4	1	-	1	-	2	5	5	7	2	4	6	37
Number having between 8 and 9 per cent. of total solids,	-	-	-	-	1	2	4	2	-	1	3	2	15
Number having less than 8 per cent. of total solids,	-	-	-	-	-	-	1	-	-	-	1	-	2
Totals,	521	243	317	173	168	533	418	455	446	343	387	687	4,691

Twenty-three samples of milk containing artificial coloring matter were collected from Gloucester, Lowell and Rockland. Of these, 13 samples contained annatto, 9 aniline orange and 1 caramel. But 20 samples of milk were found containing added preservative, — the smallest number for some years. Formaldehyde was in all cases the preservative used.

The following table shows statistics regarding the use of preservatives in milk for the last few years: —

Preservatives in Milk.

YEAR.	Samples Examined.	Number containing Formaldehyde.	Per Cent. containing Formaldehyde.	Number containing Boric Acid.	Per Cent. containing Boric Acid.	Number containing Carbonate.	Total containing Preservative.
1898,	1,046	26	2.5	11	1.0	4	41
1899,	2,105	55	2.6	13	0.6	3	71
1900,	2,018	61	3.0	6	0.3	-	67
1901,	2,154	42	1.9	12	0.5	-	54
1902,	1,934	29	1.5	14	0.7	-	43
1903,	1,935	28	1.5	11	0.4	1	40
1904,	1,863	20	1.1	-	-	-	20
Summary,	13,055	261	2.0	67	0.5	8	336

It is interesting to note the gradual decrease in the extent of the use of formaldehyde in milk since 1900. It is our custom to examine all samples of milk for preservatives through June, July, August and September. While added coloring matter in milk is usually rendered apparent to the experienced eye by the physical appearance of the milk itself, thus often giving a clue to the analyst, there is, of course, nothing at all to indicate whether preservative is present except a careful test.

The question often arises in court whether or not it is possible to analyze milk after it has become sour, since it occasionally happens in the summer time that milk from long distances sometimes reaches the laboratory not perfectly sweet. Again, it is sometimes held that certain sealed samples of milk can not be analyzed, because they are sour. As a matter of fact, while the process of lactic fermentation results in the formation of traces of volatile acids, unless the sample has become so badly curdled as to render a fine, homogeneous mixture of the various parts impossible, a perfectly fair determination of the solids and fat can readily be made. Experience has proved that, excepting in instances of milk so badly soured as to become actually putrid, the analysis of sour milk, if carefully made, should not differ materially from that of the same milk before souring.

Care must be taken to secure a fine emulsion of the curd and whey. This may sometimes be accomplished by repeatedly pouring a sample back and forth from one container to another. Again, it is sometimes necessary to use an egg-beater, especially of the spiral-wire pattern, which should preferably fit easily into the can or milk-container. Unless a fine, even emulsion can be secured, it is impossible to make a satisfactory analysis of the milk. With such an emulsion, results can be relied upon. In measuring portions of the thoroughly mixed sample of sour milk for analysis, a pipette having a large opening should be used.

Detection of Added Water.

In the analyst's report for 1903 a method was outlined for the detection of added water in milk by means of the Zeiss immersion refractometer, and additional experience with this method through the year has proved its reliability beyond a doubt. The writer knows of no other method for positively showing added water in milk, especially when the sample stands 11 per cent. or more in total solids. It has hitherto been impossible positively to allege added water in milk, unless the sample as analyzed was found to stand lower in total solids than the minimum limit for Holstein milk of known purity.

The following table shows the results of the analysis of milk of known purity taken from a herd of Holstein cows in Middlesex County, milked in the presence of the writer. These cows were kept under ordinary farm conditions, the daily ration in each case consisting of three quarts of meal, two quarts of mixed feed, and two quarts of gluten with green fodder.

Milk of Known Purity from Common Holstein Cows.

Age of Cow (Years).	Time since Calving (Months).	Determinations on Milk.								On Milk Serum.		
		Specific Gravity at 15° C.	Water (Per Cent.).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Ash (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Specific Gravity at 15° C.	Immersion Refractometer reading at 20° C.	n_D. 20°.
6	1	1.0290	87.24	12.76	4.50	8.26	0.52	4.90	2.84	1.0253	42.9	1.343842
5	2	1.0297	87.32	12.68	4.10	8.58	0.45	4.90	3.23	1.0295	43.1	1.343918
3	9	1.0305	87.87	12.13	3.55	8.58	0.55	4.35	3.68	1.0287	41.5	1.343315
8	3	1.0302	87.89	12.11	3.65	8.46	0.50	4.90	3.06	1.0291	42.0	1.343500
5	3	1.0296	88.07	11.93	3.45	8.48	0.60	4.30	3.58	1.0271	41.4	1.343278
7	1½	1.0307	88.24	11.76	3.60	8.16	0.50	4.80	2.86	1.0291	42.1	1.343538
2	3	1.0295	88.32	11.68	3.30	8.38	0.49	4.65	3.24	1.0285	41.8	1.343426
6	4	1.0300	88.60	11.40	3.05	8.35	0.60	4.55	3.20	1.0287	40.9	1.343092
5	8	1.0285	88.83	11.17	3.25	7.92	0.53	4.10	3.29	1.0286	39.7	1.342636
6	9	1.0290	88.90	11.10	3.30	7.80	0.65	3.95	3.25	1.0266	39.9	1.342712
7	7	1.0286	89.44	10.56	2.70	7.86	0.63	3.75	3.48	1.0296	39.0	1.342370
2	2	1.0286	89.55	10.45	2.60	7.45	0.59	4.25	3.01	1.0267	40.0	1.342750
Highest, .	.	1.0307	89.55	12.76	4.50	8.58	0.60	4.90	3.68	1.0296	43.1	1.343918
Lowest, .	.	1.0282	87.24	10.45	2.60	7.80	0.45	3.75	2.84	1.0253	39.0	1.342370
Average,	.	1.0295	88.35	11.65	3.45	8.22	0.54	4.45	3.23	1.0281	41.6	1.343520

From this it may be seen that milk of known purity may contain as low as 10.45 per cent. of total solids, and even this is by no means the minimum limit.

We have hitherto claimed that it is safe to assume that, if milk stands below 10.75 in total solids with a solids not fat less than 7.30, the milk may safely be condemned as fraudulently watered. The chief advantage of the refractometric method lies in its ability to detect watered milk running between 11 and 12 per cent. in total solids.

As an example of this, I would cite the case of a suspected producer in Worcester County, whose milk, standing at 11.33 per cent. in total solids and 3.8 per cent. fat, was declared to contain added water, though without the refractometric reading of the milk serum (38.3° at 20° C.) this fact could not have been established. This sample being at the time the highest total solids on which a case of alleged added water had ever been brought, it was with some misgivings that the case was prosecuted ; but the defendant, after being found guilty on the evidence, in order to relieve himself of the odium of selling watered milk, finally admitted that an employee of his, a Pole, who had been discharged by him about the time of the seizure of the milk, had been caught in the act of pouring off the tops of the cans on account of spite, and filling them up with water. This episode furnished a most satisfactory and convincing proof of the reliability of the method.

Before the minimum reading of the refractometer can be definitely fixed, it will be desirable to examine a large number of low-standard milk samples of known purity, and this, it is hoped, can be accomplished in the near future.

CONDENSED MILK.

Ninety-two samples of condensed milk were analyzed, 12 of which were found to consist of condensed skimmed milk. Following are the results of the analysis of the newer brands, or those not recorded in recent years; these were analyzed in full: —

Condensed Milk.

BRAND.	Total Solids (Per Cent.).	Water (Per Cent.).	Milk Solids (Per Cent.).	Cane Sugar (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Fat (Per Cent).	Ash (Per Cent.).	Fat in Original Milk (Per Cent.).
Regal, . . .	73.69	26.31	30.28	43.41	10.92	7.92	9.90	1.48	4.52
Triangle, . .	72.38	27.62	29.86	42.52	9.82	8.59	10.05	1.40	4.40
Brindle Cow, . .	70.77	29.23	30.80	39.97	9.84	10.08	9.30	1.58	4.03
Wingold, . .	73.48	26.52	27.60	45.88	6.87	9.75	9.30	1.60	3.94
Red Clover, . .	71.58	28.42	27.46	44.12	10.46	7.35	7.95	1.70	3.80
White Pansy, . .	72.94	27.06	32.90	40.04	11.06	11.20	9.15	1.49	3.61
Rob Roy, . .	74.14	25.86	29.63	44.51	13.02	7.85	7.20	1.56	3.31
Stamp, . . .	71.92	28.08	29.16	42.76	11.32	9.58	6.75	1.51	3.20
Jaxon, . . .	74.33	25.67	33.13	41.20	12.94	10.31	8.40	1.48	3.16
O'Keeffe's Shamrock.	75.80	24.20	31.66	44.14	12.38	9.91	7.80	1.57	3.05
Anchor, . . .	75.71	24.29	31.69	44.02	12.82	9.51	7.80	1.56	3.03
Farm Favorite, .	72.87	27.13	32.51	40.36	13.24	9.44	7.95	1.88	3.02
Middlesex, . .	75.32	24.68	33.37	41.95	13.24	10.74	7.80	1.59	2.83
Sailor Boy, . .	69.66	30.34	36.17	33.49	11.46	17.50	5.40	1.81	2.10

Evaporated "Cream."

Top Notch, . .	27.25	72.75	27.25	–	10.30	8.26	7.50	1.10	4.63
Columbia, . .	29.27	70.73	29.27	–	11.18	9.57	7.75	1.25	4.36
Ideal, . . .	34.29	65.71	34.29	–	12.36	7.75	10.20	1.45	4.43
Pet,. . . .	–	–	–	–	–	–	7.35	2.45	4.16
Borden's Peerless,.	–	–	–	–	–	–	7.80	1.43	3.64
Top Notch, . .	–	–	–	–	–	–	6.73	1.33	3.55
St. Charles, . .	–	–	–	–	–	–	6.60	1.64	2.85
Top Notch, . .	29.51	70.49	29.51	–	11.24	9.23	6.90	1.23	2.84

The following are old brands, or those previously examined, determinations of the fat and ash only being made in each case in order simply to ascertain the general quality of the milk: —

Condensed Milk.

Brand.	Ash (Per Cent.).	Fat (Per Cent.).	Fat in Original Milk (Per Cent.).	Brand.	Ash (Per Cent.).	Fat (Per Cent.).	Fat in Original Milk (Per Cent.).
Lennox, . .	1.65	10.35	4.39	Willow Farm, .	1.62	7.80	3.41
Owl, . . .	1.64	10.20	4.33	Jaxon, . .	1.80	8.70	3.38
Something New, .	1.51	9.30	4.32	Eagle, . . .	1.67	7.95	3.32
Challenge, . .	1.30	7.80	4.20	Winner, . .	1.59	8.40	3.27
Perfection, . .	1.55	9.00	4.07	Eagle, . . .	1.55	7.20	3.25
Defiance, . .	1.49	8.55	3.99	Gray's, . .	1.83	8.25	3.17
Tip Top, . .	1.67	9.45	3.95	Purity, . .	1.69	7.20	2.96
Vermont, . .	1.38	7.80	3.90	Chief, . . .	1.58	6.37	2.82
Rose, . . .	1.68	9.45	3.88	Regal, . . .	1.60	6.30	2.74
Nestler, . .	1.69	8.85	3.64	Rooster, . .	2.07	7.95	2.71
Merit, . . .	1.63	8.55	3.62	Silver, . . .	1.94	7.50	2.70
Ginter's, . .	1.59	8.25	3.61	O'Keeffe's, . .	1.57	6.15	2.69
Blue Bell, . .	1.65	8.22	3.49	O'Keeffe's, . .	1.60	6.00	2.62
Standard, . .	1.52	7.50	3.45	Plume, . .	1.54	5.40	2.46
Connor's, . .	1.86	9.00	3.41				

While it is impossible to determine exactly the quality of the original milk from the analysis of a condensed sample of sugar-preserved milk, quite satisfactory approximate results have been obtained by the methods published in our former reports. A more satisfactory method of calculating the fat in the original milk consists in reducing the fat and the milk solids to the basis of the cane-sugar-free sample. This is done by dividing the per cent. of each as found in the sample by 100, less the percentage of cane sugar, and multiplying the result by 100; then ascertaining the difference between the milk solids and the fat thus obtained in the cane-sugar-free sample, and dividing this percentage of milk solids not fat by 9.3, which is assumed as the percentage of solids not fat in the original milk. The result is "the number of times condensed" (if cane sugar were not present as a diluent). The per cent. of fat in the cane-sugar-free sample, divided by "the number of times condensed," as above obtained, gives approximately the percentage of fat in the original milk.

By assuming the highest reasonable figure for solids not fat, it is readily seen that the highest result is obtained for the fat in the original milk; and hence the benefit of any doubt as to the use of skimmed milk is given to the manufacturer.

CREAM.

Seven samples of cream were examined for preservatives, 1 of which was found to contain formaldehyde.

BUTTER.

Two hundred and seventeen samples of butter were examined, of which 8 were declared adulterated, being "renovated butter" sold without proper regard to labelling. It should be said that many more samples of "renovated butter" were received, but, with the exception of 8, all were sold and marked in accordance with the law.

CHEESE.

Sixty samples of cheese were examined, of which 13 were pronounced adulterated, 2 of these by reason of the fact that they were skimmed-milk cheese, and 1 as containing boric acid without being labelled. A skimmed-milk cheese is at once indicated if the fat is considerably less than the proteids.

The following brands of cheese were found to be adulterated: —

Published Results of Analyses of Cheese.

VARIETY.	Brand.	Results of Analyses.
Neufchatel, . . .	Worcester County M. R. B.,	Skimmed-milk cheese.
Neufchatel, . . .	Crescent, ...	Skimmed-milk cheese.
Soft cheese, . . .	MacLaren's Imperial, .	Preserved with boric acid; no formula.

MacLaren's Imperial cheese, it should be said, was afterwards sold in packages bearing a formula specifying the presence of boric acid, in accordance with the law.

COCOA.

Twenty-one samples of cocoa were examined, of which 17 were found to be adulterated. The adulterants found were, as usual, sugar, corn and wheat starches, and cocoa shells. The presence, under the microscope, of an abnormally large number of yellow and brown fragments in the water-mounted cocoa specimen, even under small magnification, rouses suspicion of the presence of shells, the most distinct elements of which are the spongy tissue, the stone shells and the abundant spiral ducts, the latter being scarce in pure cocoa powder. Cocoa shells are indicated on chemical analysis by the abnormally high ash and crude fiber.

The following brands of cocoa were published in the monthly bulletins as being adulterated: —

Published Results of Analyses of Cocoa.

BRAND.	Manufacturer or Wholesaler.	Result of Analysis.
Homestead Breakfast, "Guaranteed absolutely pure."	E. V. Miller, Cash Grocer, Rockland, Mass.	Admixture of cornstarch.
Superior Lunch Cocoa, manufactured in America, "Warranted pure,"	-	Large admixture of sugar.
Sterry's,	Sterry & Sterry, New York,	Cocoa shells.
Acme Lunch Cocoa,	Brewster Cocoa Manufacturing Company, Jersey City, N. J.	Large admixture of sugar and wheat.

COFFEE.

Of the 90 samples examined, 4 were found to be adulterated, the adulterants found being peas, pea hulls, chicory and sugar. Two brands reported as adulterated were "Coffey's Soluble Coffee, Premium Brand," put out by the Fulton Mills, New York, containing 30 per cent. sucrose, without a proper label; and "Café des Invalides, or Antidote Coffee," manufactured by the S. S. Pierce Co. of Boston, a compound not labelled according to law.

A careful examination of the crushed grains of the ground coffee sample with the naked eye will often serve to detect, and in some cases identify, certain adulterants, especially cereal grains, peas and chicory. A still more effective method of examining the grains themselves consists in the use of a dissecting microscope with a low-power magnifier, observing the grains as they lie scattered over a white enamel plate. The writer uses for this purpose a dissecting microscope with an inch and a half objective, mounted in a Bausch and Lomb compound erecting eyepiece.

The chicory grains are apparent from their dark and somewhat gummy appearance, and can usually be recognized by crushing them between the teeth. Their soft consistency and bitter taste are very distinctive. The dull surface of the outside of the crushed coffee grains is in marked contrast to the polished appearance of the surface of the broken peas or beans often to be found as adulterants, while fragments of broken cereal grains are readily distinguished from coffee with a low-power magnifier, though perhaps not easily identified by the eye alone.

Fifteen samples of coffee of known purity (3 each of the following brands: Santos, Porto Rico, Rio, Mocha and Java coffee) were analyzed in full in this laboratory by H. C. Lythgoe, who, as referee on tea and coffee of the Association of Official Agricultural Chemists, has been working up methods of analysis of these products for provisional adoption by the association.

The following are the results of these analyses, together with those of several samples of coffee substitutes and of adulterated coffee taken from samples collected: —

TABLE 1. — *Analyses of Roasted Coffee.*

VARIETY.		Moisture (Per Cent.).	Ash (Per Cent.).	Water-soluble Ash (Per Cent.).	Sand (Per Cent.).	Chlorine (Per Cent.).	Alkalinity of Ash of 1 Gram of Substance (c.c. n/10 Acid).	Alkalinity of 1 Gram of Ash (c.c. n/10 Acid).	Soluble P_2O_5 (Per Cent.).	Insoluble P_2O_5 (Per Cent.).	PETROLEUM ETHER EXTRACT. (Per Cent.).	PETROLEUM ETHER EXTRACT. $n_D 30°$.	Total Nitrogen (Per Cent.).
Santos,	A,	1.40	4.16	3.46	.00	.023	2.97	71.4	.319	.346	14.58	1.4754	2.26
	B,	1.87	4.31	3.62	.00	.023	3.36	75.7	.286	.295	13.84	1.4754	2.26
	C,	1.31	3.80	3.00	.00	.019	3.35	85.6	.273	.295	13.86	1.4750	2.39
Porto Rico,	A,	1.29	4.05	3.30	.00	.016	3.53	87.2	.305	.337	13.00	1.4752	2.28
	B,	1.26	4.06	3.27	.00	.020	3.72	92.6	.226	.351	13.34	1.4750	2.26
	C,	1.48	4.12	3.32	.00	.016	3.66	88.8	.333	.328	14.12	1.4760	2.33
Rio,	A,	1.76	4.06	3.40	.00	.020	4.16	102.3	.213	.166	13.38	1.4758	2.14
	B,	2.34	3.91	3.24	.00	.021	3.17	81.2	.356	.227	13.71	1.4753	2.18
	C,	2.10	3.74	3.06	.00	.023	3.22	86.6	.363	.236	13.53	1.4756	2.26
Mocha,	A,	2.05	4.05	3.25	.00	.016	3.94	97.4	.282	.351	14.84	1.4737*	2.28
	B,	2.95	3.85	3.07	.00	.021	3.26	84.7	.333	.364	14.47	1.4743*	2.00
	C,	2.40	3.80	3.00	.00	.012	3.54	93.3	.337	.545	15.18	1.4740*	2.02
Java,	A,	3.34	4.09	3.27	.00	.016	3.88	95.0	.258	.421	12.61	1.4752	2.48
	B,	3.35	4.38	3.56	.00	.019	3.54	80.8	.194	.388	12.28	1.4758	2.35
	C,	3.44	3.96	3.10	.00	.011	2.95	74.5	.235	.383	13.54	1.4752	2.56
Highest,		3.44	4.38	3.62	.00	.023	4.16	102.3	.424	.545	15.18	1.4760	2.56
Lowest,		1.29	3.74	3.00	.00	.011	2.95	71.4	.194	.166	12.28	1.4750	2.00
Average,		2.16	4.03	3.26	.00	.018	3.55	87.1	.285	.329	13.75	1.4754	2.27

* Omitted from average.

TABLE 1. — *Analyses of Roasted Coffee* — Concluded.

VARIETY.		Cold-water Extract (Per Cent.).	Alcohol Extract (Per Cent.).	Reducing Sugars (Per Cent.).	"Starch"* by Diastase (Per Cent.).	Crude Fiber (Per Cent.).	Caffeine (Per Cent.).	TEN PER CENT. EXTRACT. Specific Gravity at 15°.	TEN PER CENT. EXTRACT. Immersion Refractometer Reading at 20°.	TEN PER CENT. EXTRACT. Index of Refraction at 20° (n_D).	TEN PER CENT. EXTRACT. Solids (Per Cent.).	TEN PER CENT. EXTRACT. Ash (Per Cent.).
Santos,	A,	20.80	16.83	0.52	2.28	13.41	1.25	1.0107	26.7	1.33770	2.64	.40
	B,	22.72	17.11	0.58	1.00	11.02	1.10	1.0108	26.9	1.33777	2.66	.39
	C,	21.70	17.80	0.75	2.32	14.71	1.20	1.0101	26.0	1.33743	2.46	.30
Porto Rico,	A,	22.48	15.70	0.50	2.17	13.11	1.38	1.0107	26.6	1.33766	2.60	.37
	B,	21.76	16.36	0.63	1.58	12.93	1.21	1.0104	26.3	1.33754	2.50	.36
	C,	24.44	16.91	0.54	2.62	12.50	1.32	1.0113	27.6	1.33804	2.77	.30
Rio,	A,	22.66	17.00	0.68	2.82	14.08	1.11	1.0103	25.5	1.33724	2.48	.40
	B,	22.61	17.34	0.78	1.47	13.10	1.10	1.0101	25.8	1.33735	2.46	36
	C,	22.75	17.37	0.61	2.62	11.91	1.17	1.0101	26.0	1.33743	2.46	.30
Mocha,	A,	24.00	18.01	1.78	2.30	11.22	1.16	1.0106	26.4	1.33758	2.65	.40
	B,	20.27	17.96	0.94	1.85	12.34	1.10	1.0101	26.3	1.33754	2.47	.36
	C,	24.18	19.55	1.42	2.90	13.20	1.18	1.0111	27.3	1.33793	2.72	.40
Java,	A,	23.85	15.95	0.32	2.95	13.43	1.34	1.0110	26.9	1.33777	2.63	.39
	B,	22.19	15.45	0.42	2.32	13.77	1.30	1.0107	26.5	1.33762	2.58	.38
	C,	23.20	16.21	0.66	3.34	14.75	1.27	1.0108	26.6	1.33766	2.62	.38
Highest,		24.44	19.55	1.78	3.34	14.75	1.34	1.0113	27.6	1.33804	2.77	.40
Lowest,		20.27	16.45	0.32	1.00	11.02	1.00	1.0101	26.0	1.33743	2.46	.30
Average,		22.63	17.03	0.75	2.30	13.03	1.20	1.0105	26.6	1.33766	2.72	.37

* Reducing substance not starch but reckoned as such.

TABLE II. — *Analyses of Coffee Substitutes and of Adulterated Coffee.*

VARIETY.	Moisture (Per Cent.).	Ash (Per Cent.).	Water-soluble Ash (Per Cent.).	Sand (Per Cent.).	Chlorine (Per Cent.).	Alkalinity of Ash of 1 Gram of Substance (c.c. n/10 Acid).	Alkalinity of 1 Gram of Ash (c.c. n/10 Acid).	Soluble P_2O_5 (Per Cent.).	Insoluble P_2O_5 (Per Cent.).	PETROLEUM ETHER EXTRACT.		Total Nitrogen (Per Cent.).
										Per Cent.).	$n_D30°$.	
Roasted wheat, .	5.60	5.71	2.82	.00	–	0.34	6.0	.649	1.460	2.40	–	1.84
Roasted chicory, .	5.55	4.37	2.27	.81	.080	0.95	21.8	.277	0.314	0.88	–	1.10
Coffee and chicory, .	5.08	3.96	3.14	.06	.026	3.05	77.0	.286	0.323	8.32	–	1.89
Coffee, chicory and pea hulls.	3.64	4.97	4.05	.24	*.284	2.60	65.6	.472	0.740	9.56	–	2.17

* Admixture of salt.

TABLE II. — *Analyses of Coffee Substitutes and of Adulterated Coffee* — Concluded.

VARIETY.	Cold-water Extract (Per Cent.).	Alcohol Extract (Per Cent.).	Reducing Sugars (Per Cent.).	Starch by Diastase (Per Cent.).	Crude Fiber (Per Cent.).	Caffeine (Per Cent.).	TEN PER CENT. EXTRACT.				
							Specific Gravity at 15°.	Immersion Refractometer Reading at 20°.	Index of Refraction at 20° (n_D).	Solids (Per Cent.).	Ash (Per Cent.).
Roasted wheat, .	25.88	10.72	4.10	28.58	6.23	0.00	–	–	–	–	–
Roasted chicory,	72.92	34.39	19.34	2.10	5.91	0.00	1.0307	45.0	1.34163	7.44	.26
Coffee and chicory.	31.79	21.66	5.06	2.21	14.31	0.95	1.0142	30.5	1.33915	3.62	.29
Coffee, chicory and pea hulls.	25.00	14.25	3.00	3.78	17.87	1.00	–	–	1.47450	–	–

For these methods in full, see "Proceedings of the Twenty-first Annual Convention of the Association of Official Agricultural Chemists."

CONFECTIONERY.

Of 34 samples analyzed, one only was pronounced adulterated, by reason of the presence of an undue amount of paraffine.

CREAM OF TARTAR.

Two hundred and seventy samples were analyzed, 6 of which were adulterated. The adulterants found were calcium acid phosphate, gypsum and starch. Most of the adulterated brands were bulk goods, but one, the Star Brand of Pulverized Cream of Tartar, "extra fine, guaranteed as to quality and strength," was found to contain a large admixture of the above adulterants.

FLAVORING EXTRACTS.

Almond Extract.

Twenty-four samples were examined, 4 of which were found to contain hydrocyanic acid. According to the Pharmacopœia, essence of bitter almonds should contain 1 per cent. by volume of almond oil in strong alcohol. The official essence of the Pharmacopœia does not specify that the almond oil used should be perfectly free from hydrocyanic acid, in spite of the fact that its highly poisonous nature is well known, and that it exists in the crude oil to the extent of from 4 to 6 per cent. True, but little of it is found in the extract; but in these days, when the unannounced presence in food of such substances as antiseptics and coloring matters is regarded as questionable from a sanitary stand-point, in spite of the fact that their physical effects on man are still matters of controversy, there should be little hesitancy in pronouncing the presence of prussic acid objectionable, especially when a pure almond oil entirely free from it is readily obtainable.

The presence of nitrobenzol or oil of mirbane as a substitute for almond oil was looked for, but was not found in any of the extracts sold in this market. The following methods were employed: —

Distinction between Benzaldehyde and Nitrobenzol. — Treat 20 cubic centimeters of the extract with 5 to 10 cubic centimeters of a cold, saturated solution of sodium bisulphite in a test tube, and shake vigorously. Transfer to an evaporating dish, and heat on the water bath until the alcohol is driven off. At this stage benzaldehyde remains in the heated solution as a crystalline solid, and the solution gives off no almond odor. Nitrobenzol, on the contrary, does not combine with the bisulphite, and is insoluble, forming globules of oil on the surface of the heated liquid, and, in addition, giving off the pungent odor so characteristic of the substance.

Determination of Benzaldehyde. — In case nitrobenzol by the qualitative test is found to be absent, shake vigorously 50 cubic centimeters of the extract with 20 cubic centimeters of the saturated sodium bisulphite solution in a stoppered flask, transfer to an evaporating dish, and heat on the water bath till the alcohol has disappeared, keeping up the original volume by the occasional addition of water. Note the odor of the solution at frequent intervals during evaporation, and if at any time the least odor of escaping benzaldehyde is apparent, stir in at once a few drops more of the bisulphite solution. Cool, dilute with water slightly, make strongly alkaline with sodium hydroxide, and extract in a separatory funnel with four portions of low-boiling petroleum ether, of 15 to 20 cubic centimeters each. Wash the combined petroleum ether twice with water, and, after removal of the water, transfer it to a tared dish, and allow it to evaporate spontaneously at room temperature. Finally, weigh the residue.

By reason of the volatility of benzaldehyde and its tendency to oxidize to benzoic acid, the results are only approximate.

Separation of Nitrobenzol and Benzaldehyde. — If by the qualitative test nitrobenzol is found, shake vigorously as before 50 cubic centimeters of the extract with 10 cubic centimeters of the saturated sodium bisulphite solution in a corked flask, and transfer with 100 cubic centimeters of water to a large separatory funnel. Shake out the nitrobenzol from the solution with four successive portions of petroleum ether, of 15 to 20 cubic centimeters each, and after washing with water the combined petroleum ether, transfer it to a tared dish, in which it is allowed to evaporate spontaneously.

It is extremely difficult to avoid loss of some of the nitrobenzol by this process, but, even if the weighed residue fails to show the full amount originally used, enough will usually be extracted to admit of testing on the refractometer, and of otherwise verifying its character.

After removal of the nitrobenzol, make the residual solution in the separatory funnel strongly alkaline with sodium hydroxide, and shake out the benzaldehyde, if present, with petroleum ether, as previously described. If after making the solution alkaline no odor of benzaldehyde is apparent, the absence of benzaldehyde may be inferred.

Distinction between Artificial Benzaldehyde and Pure Almond Oil. — Test the final residue from the ether extract by shaking with an equal volume of concentrated sulphuric acid in a test-tube. With natural oil of almonds a clear, brilliant, but dark currant-red color is produced; while with artificial benzaldehyde the acid produces a dirty brown color, with the formation of a precipitate.

Determination of Alcohol. — In the absence of other flavoring substances than nitrobenzol and benzaldehyde, which are rarely present to an extent exceeding 1 per cent., a sufficiently close approximation for most purposes can be gained by estimating the alcohol from the direct specific gravity of the extract.

Detection of Hydrocyanic Acid. — To a few cubic centimeters of extract in a test-tube add a few drops of a mixture of solutions of ferrous sulphate and ferric chloride, the ferrous salt being in excess. Make alkaline with sodium hydroxide, and add enough dilute hydrochloric acid to dissolve the precipitate formed by the alkali. Presence of a blue coloration or precipitate, due to the formation of Prussian blue, indicates hydrocyanic acid. The reaction is very delicate.

*Determination of Hydrocyanic Acid.** — Hydrocyanic acid may be determined by titration with tenth-normal silver nitrate solution. Twenty-five cubic centimeters of the extract are measured into a flask, and 5 cubic centimeters of freshly prepared magnesium hydroxide suspended in water are added, or enough to make the reaction alkaline.

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* Vielhaber, Arch. Pharm. (3), 13, 408.

A few drops of a solution of potassium chromate are then introduced, and the tenth-normal silver nitrate solution added, till, with shaking, the formation of the red silver chromate indicates the end-point. One cubic centimeter of silver solution equals .0027 gram of hydrocyanic acid.

Banana Extract.

Two samples of "banana extract" were examined, both of which, being plainly marked artificial, were adjudged in accordance with the law.

It is obviously a fraud to put out these synthetic or artificial fruit essences as "pure fruit extracts."

Jamaica Ginger Extract.

The single sample of this extract brought in for analysis was pronounced adulterated, containing a trace only of ginger oil. This was the "Banner" brand, Simpson Spring Company, Boston.

Lemon Extract.

Thirty-two samples were examined, of which 19 were pronounced adulterated. Lemon extracts sold as pure, without formulæ and containing no lemon oil whatever, though very common in our market two or three years ago, are now rarely found. Nearly all the cheap extracts bear some variety of formula, but in many cases the formula is incorrect, if not entirely misleading.

The following brands of lemon extract were advertised as adulterated: —

Published Results of Analyses of Lemon Extracts.

BRAND.	Manufacturer and Wholesaler.	STATEMENT ON FORMULA.		RESULT OF ANALYSIS.	
		Lemon Oil (Per Cent.).	Alcohol (Per Cent.).	Lemon Oil (Per Cent.).	Alcohol (Per Cent.).
——,	Walker Chemical and Extract Company, Chelsea, Mass.,	3.0	66.00	0.94	59.80
——,	Ragus Tea and Coffee Co., New York,	–*	–*	0.60	60.00
——,	L. W. Manning, Somerville, Mass.,	–*	–*	1.40	51.80
Kidder's Concentrated,	Kidder & Co., Boston, Mass.,	–*	–*	1.30	70.90
Royal Arms,	International Extract Company, New York,	–*	–*	0.00	–†
Acme,	Acme Extract Co., Binghampton, N. Y.,	–*	–*	0.60	37.34
——,	E. M. Chace Tea Co., Manchester, N. H.,	–*	–*	3.30	79.60
——,	Zopher Company, Lowell, Mass.,	–*	–*	0.10	48.75
——,	Elmo Extract Company, Somerville, Mass.,	3.0	–	1.40	44.19
——,	Eagle Extract Company, Boston, Mass.,	3.0	–	1.80	–
Favorite,	Highland Extract Company, Boston, Mass ,	2.3	–	trace	–
Pure concentrated,	– –	–*	–*	0.00	–
——,	Oriental Drug Company, Boston, Mass.,	2.5	–	0.10	–
Derby,	Derby Food Producing Co., Boston, Mass.,	3.0	70.00	1.00	50.11

* No formula. † Cane sugar present.

Orange Extract.

The single sample of this extract examined was found to be of good quality.

Peppermint Extract.

Two samples of peppermint extract were examined, one of which, put out by Harrison & Co. of Providence, R. I., contained only a trace of oil of peppermint, with 16 per cent. alcohol by volume.

Vanilla Extract.

Thirty samples were analyzed, of which 3 were pronounced adulterated.

HONEY.

Forty-two samples were examined, 4 of which were adulterated. The usual adulterants found were glucose and cane sugar.

The following brands were published as adulterated : —

Published Results of Analyses of Honey.

BRAND.	Manufacturer or Wholesaler.	Results of Analysis.
Wild Rose California, . . .	San Diego Honey Company, San Francisco, Cal.	Admixture of glucose and cane sugar.
Jamaica Mountain, . . .	Smith & Cheeney, Boston, Mass., .	Admixture of glucose and cane sugar.

LARD.

Twenty-five samples were examined, 9 of which were found to be adulterated with cotton-seed stearine. The presence of cotton-seed oil is best indicated by Halpen's test.

MAPLE SUGAR AND SYRUP.

Eighteen samples of maple sugar were examined, 6 of which were found adulterated with refined cane sugar. Forty-six samples of the syrup were analyzed, 28 of which were similarly adulterated.

The presence of refined cane sugar in maple products is readily detected in a positive manner, though the popular belief still holds that pure white sugar cannot be detected. As a matter of fact, it is the impurities of the maple sugar in the strict sense of the term that give to it its commercial value, and in so far as these impurities are diluted or displaced by the pure or refined sugar, to just such an extent is the adulteration rendered apparent.

The Hortvet centrifugal method of measuring the precipitate, caused by treatment of the sample in solution with lead acetate, taken in connection with the amount and character of the ash, are almost invariably sufficient to determine the purity of the product, excepting in the case of molasses or brown sugar, in which case a determination of the reducing sugars in addition is necessary.

The following brands of maple syrup were found to be adulterated : —

Published Results of Analyses of Maple Syrup.

BRAND.	Name and Address of Manufacturer, Wholesaler or Producer.	RESULTS OF ANALYSES.								
				CALCULATED TO DRY SUBSTANCE.						
		Polarization.	Moisture (Per Cent.).	Ash (Per Cent.).	Water Soluble Ash (Per Cent.).	Alkalinity of Ash of 1 Gram of Syrup (c. c. n/10 Acid).	Alkalinity of 1 Gram of Ash (c. c. n/10 Acid).	Reducing Sugars (Per Cent.).	Hortvet Test (c. c.).	Per Cent. of Refined Cane Sugar Syrup.
——,	E. E. Gray, Company, Boston, Mass.,	61.2	34.31	.13	.08	.21	169	4.80	0.75	85
——,	J. H. Folkins & Co., Boston, Mass.,	61.2	32.56	.14	.09	.13	89	3.50	1.26	85
Metropolitan,	J. H. Folkins & Co., Boston, Mass.,	59.4	31.84	.15	.09	.19	125	7.13	0.78	80
Metropolitan,	J. H. Folkins & Co., Boston, Mass.,	21.1	36.79	.27	.17	.27	99	36.37	0.44	–*
Manhattan,	J. H. Folkins & Co., Boston, Mass.,	60.0	30.01	.17	.10	.17	100	7.92	0.61	80
Spindle City,	Mansfield, Whitam & Co., Lowell, Mass.,	64.6	30.39	.17	.14	.11	65	3.09	0.36	80
——,	W. A. Little & Co., Andrew Square, Boston, Mass.,	59.6	35.80	.03	.01	.04	122	6.15	0.23	90
——,	W. A. Little & Co., Andrew Square, Boston, Mass.,	64.0	31.34	–	–	–	–	–	0.64	70
Brunswick,	Eldridge, Baker & Bain, Boston and Salem, Mass.,	61.0	30.85	.19	.12	.14	82	5.32	0.87	75
Victor,	Saville, Somes & Co., Boston, Mass.,	61.2	34.82	.08	.03	.07	114	6.59	0.00	90
——,	E. D. Pettengill Company, Portland, Me.,	60.4	27.33	.26	.23	.33	128	4.04	0.41	65
——,	E. T. Cowdrey & Co., Boston, Mass.,	59.8	33.39	.41	.32	.36	87	4.23	0.84	50†
Champion,	C. A. Reed, Medford, Mass.,	64.0	26.45	.15	.07	.13	87	3.42	0.24	80
Whitcher's. "Warranted pure,"	Ayer Preserving Company, Ayer, Mass.,	65.0	25.27	.08	.06	.09	114	1.35	0.00	95
Victor,	Simpson Spring Company, South Easton, Mass.,	65.7	22.62	.15	.10	.19	119	2.56	0.04	80
Boston,	J. P. & D. Plummer, Boston, Mass.,	61.3	28.52	.11	.07	.15	131	3.57	0.25	85
Green Mountain,	W. J. Lamb, West Somerville, Mass.,	61.1	33.52	.18	.11	.23	127	4.50	0.84	75
Golden Tree,	New England Maple Syrup Company, Boston, Mass.,	60.4	29.08	.16	.10	.13	87	5.41	0.45	80
Green Mountain,	Haskell, Adams & Co., Boston, Mass.,	62.3	34.53	.06	.02	.07	120	2.84	0.12	90
Rival,	Haskell, Adams & Co., Boston, Mass.,	60.0	32.88	.21	.12	.01	72	2.49	1.19	70
Fancy Vermont. "Guaranteed pure,"	Haskell, Adams & Co., Boston, Mass.,	62.2	29.36	.07	.03	.03	40	1.59	0.43	90
——,	Cobb, Bates & Yerxa, Boston, Mass.,	61.7	27.23	.47	.22	.91	194	3.29	1.73	45
Gold Leaf,	Huntington Maple Syrup and Sugar Co., Providence, R. I.,	61.0	28.54	.15	.05	.38	245	5.87	1.12	80
Moody's Matchless,	Charles E. Moody & Co., Boston, Mass.,	50.6	32.25	.16	.06	.50	324	10.87	1.10	80

* Seventy per cent. brown sugar syrup.

† "This syrup is guaranteed to be made from pure maple and cane sugar, and contains no glucose."

MOLASSES.

Sixty-nine samples were examined, 5 of which were adulterated by reason of the presence of commercial glucose. The worst sample contained 54.8 per cent. of glucose.

SPICES.

Gross adulteration of this class of condiments with absolutely foreign material is now much less prevalent in the Massachusetts market than formerly. Where a few years ago it was not uncommon to find samples with from 20 to 80 per cent. of such adulterants as cocoanut shells, ground fruit stones and cereal starches, to-day the tendency is to cheapen these products by the use of low-grade or inferior spice materials, or by refuse products from the stems or adjoining plant tissues which furnish the spices themselves. Thus, for example, in cloves we find now more than formerly a larger proportion of clove stems; while the pepper shells left in the process of decorticating the berries for white pepper are themselves ground and sold as black pepper, or used as a common adulterant thereof.

Exhausted spices left as a residue from the manufacture of the expensive volatile spice oils are often used as the basis of many of the cheaper grades of these spices. This is especially true in the case of cassia, ginger and cloves.

It is very rare that the microscope will fail to detect the presence of any foreign substance in spice, and hence its use is indispensable in the examination of this class of foods. On account of the changed character of the adulteration of spices, as above indicated, chemical methods are becoming more and more necessary, showing in some cases adulteration not readily apparent by the microscope, especially in the case of exhausted spices, or those deprived of the whole or a part of their volatile oil. Sophistication of this kind is indicated best by the ether extract.

Allspice. — One hundred and fifty-nine samples were examined, 5 of which were adulterated. The common adulterants found were exhausted cloves and ginger.

Cassia. — Only 1 sample out of 192 examined during the year was found to be adulterated, this containing a large admixture of roasted wheat, foreign wood fiber and dirt.

Cayenne. — All 50 of the samples submitted for examination were found to be pure.

Cloves. — Of 166 samples analyzed, 16 were found to be adulterated. The most common form of adulteration was found to consist in the use of an excess of clove stems. Exhausted cloves and ginger were also found as adulterants.

Clove stems are best identified under the microscope by the large number of bast fibers and stone cells, and should not be found in pure cloves in excess of 5 per cent. They are also rendered apparent by the abnormally high crude fiber, which in straight clove stems amounts to from 13 to 19 per cent. The use of exhausted cloves is indicated by the determination of the volatile ether extract, which in pure cloves is rarely lower than 11 per cent. In one instance, where the presence of exhausted cloves was alleged, the volatile ether extract was as low as 6.72 per cent., and in another instance 7.27 per cent. Note the first two samples in the table of adulterated spices.

Ginger. — Two hundred and sixteen samples were examined, 4 of which were found to be adulterated. The worst sample consisted largely of wheat and buckwheat. Other adulterants found were turmeric and exhausted ginger.

Two kinds of exhausted ginger are commercially available for admixture with ground spice as an adulterant. One is the product left after extraction with strong alcohol in the making of extract of ginger, and the other the residue from the extraction, with either very dilute alcohol or water, in the manufacture of ginger ale. Ground exhausted ginger is rarely substituted wholly for the pure spice, since its lack of pungency would at once indicate its presence. It is rather used in varying proportions in admixture with the pure spice. Indeed, it is found as a common adulterant not only of ginger, but also of other spices.

The alcohol-extracted variety of exhausted ginger is of course rendered apparent, when present in considerable amount, by the low alcohol and ether extract; while the water-extracted variety is indicated by an abnormally low cold-water extract and water-soluble ash.

One sample, the analysis of which indicated the presence of the water-extracted variety, showed a cold-water extract of 11.45 per cent. and a soluble ash of 1.11 per cent.

Mustard. — Two hundred and twenty-six samples were examined, 31 of which were pronounced adulterated. The most common adulterants were mustard hulls in excess, together with frequent examples of the starch-containing weed seed so indicative of Dakota mustard. The wheat and turmeric mixtures, which ten years ago were so commonly sold as mustard, containing, as a rule, less than 10 per cent. of pure mustard, are now rarely found in this State, and only 3 samples of this variety were found this year, two of which were bulk goods, and the other Sadtler's "Celebrated Old English Mustard." (See following table of adulterated spices.)

Mace. — Thirty-one samples were examined, 12 of which were found to be adulterated in nearly every instance with wild or Bombay mace, and in some cases with corn starch. One sample of bulk goods was found to consist almost entirely of corn starch and wild mace. The microscope at once indicates when Bombay mace is present in a sample. The oil glands in the outer layers of Bombay mace are very strongly colored, and contain a deep-red resinous substance, very different from anything to be found in true mace. The glands of the more interior layers of wild mace have, moreover, a balsam-like substance, of a bright yellow color. The presence of Bombay mace is indicated under the microscope by the presence of both the red and the yellow lumps in a water-mounted sample of the spice.

Nutmeg. — One sample of the 16 examined was found to be adulterated. This was found to consist almost entirely of wild mace, containing no nutmeg whatever.

Pepper. — Three hundred and forty-six samples were examined, 13 of which were found to be adulterated. The worst sample consisted largely of wheat starch. (See that of the Ragus Tea and Coffee Company, in the following table of adulterated spices.)

The most common adulterant was found to be pepper shells in excess of the proportion found in the whole ground berry. The presence of an abnormally large amount of pepper shells is indicated by the high ash, the limit of ash fixed by the United States standard for pepper being 7 per cent. The microscope will usually indicate an undue proportion of pepper shells by reason of the excess of the stone cells of the outer coating of the berry.

The following list of adulterated brands of spices is only a small part of those found to be adulterated during the year, because it is for the most part in bulk goods, bearing no clue to the manufacturer, that the worst forms of adulteration are to be expected.

Published Results of Analyses of Spices.

SPICE.	Brand.	Manufacturer or Wholesaler.	Results of Analyses.
Cloves,	Eastern,	American Japan Tea Company, Springfield, Mass.	Largely clove stems and exhausted cloves.
Cloves,	O K,	M. O'Keeffe, Boston, Mass.,	Admixture of exhausted cloves.
Ginger,	– –	Ragus Tea and Coffee Company, New York.	Admixture of wheat and buckwheat.
Ginger,	Eastern,	American Japan Tea Company, Springfield, Mass.	Admixture of exhausted ginger.
Ginger,	Royal. "Guaranteed absolutely pure."	Dwinell Wright Company, Boston, Mass.	Large admixture of turmeric.
Mustard,	Eureka. "Absolutely pure."	H. Belanger, Haverhill, Mass.,	Excess of starch-containing weed seed.
Mustard,	Extra Strong, Double Superfine.	– –	Mustard hulls.
Mustard,	– –	B. Fischer & Co., New York,	Colored with turmeric.
Mustard,	Ardenter,	W. S. Dean & Son, New York,	Admixture of starch and turmeric.
Mustard,	Double Superfine,	B. F. Fischer & Co., New York.	Large admixture of turmeric.
Mustard,	Victor,	Saville, Somes & Co., Boston, Mass.	Admixture of starch-containing weed seed.
Pepper,	– –	Ragus Tea & Coffee Company, New York.	Admixture of foreign starch.
Pepper,	– –	Ragus Tea & Coffee Company, New York.	Large admixture of wheat.

TEA.

Fifty samples were examined. all of which were genuine.

VINEGAR.

Thirty-four samples were analyzed, of which 20 were condemned, either because they were found below the standard of total solids or of acid as fixed by law, or because in cases where they were sold for pure cider vinegar the analysis showed that this was untrue.

In addition to the cider vinegars, 3 samples of malt vinegar were examined, and pronounced of good standard quality.

Following is a summary of the results of analyses of 31 samples of cider vinegar found to be pure : —

Cider Vinegar Above Standard, 31 Samples.

	Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm. Ventzke).	Malic Acid Tests.	
					Lead Acetate.	Calcium Chloride.
Highest, ...	5.12	3.10	.42	—3.00	Positive, .	Positive.
Lowest, ...	4.50	2.10	.20	—0.60	Positive, .	Positive.
Average, ...	4.75	2.39	.31	—2.02	Positive, .	Positive.

The following table shows the results of analyses of 14 samples of vinegar below the standard : —

Cider Vinegar Below Standard, 14 Samples.

Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm. Ventzke).	Malic Acid Tests.	
				Lead Acetate.	Calcium Chloride.
5.70	0.98	.19	—0.5	Positive, . .	Positive.
5.12	1.60	-	—0.7	Positive, . .	Positive.
5.06	1.90	.25	—2.3	Positive, . .	Positive.
4.84	1.98	.20	—0.4	Positive, . .	Positive.
4.84	1.14	.18	—0.7	Positive, . .	Positive.
4.76	1.20	.28	—0.4	Positive, . .	Positive.
4.70	1.78	-	—1.4	Positive, . .	Positive.
4.68	1.90	.10	—1.1	Positive, . .	Positive.
4.68	1.46	.29	—1.1	Positive, . .	Positive.
4.64	1.98	.26	—2.0	Positive, . .	Positive.
4.59	1.84	-	—2.1	Positive, . .	Positive.
4.48	2.23	-	—1.6	Positive, . .	Positive.
4.44	2.08	.26	—2.7	Positive, . .	Positive.
4.43	2.40	-	—1.3	Positive, . .	Positive.

Following are the results of 5 samples bought for cider vinegar, but which proved not to be the product of pure apple juice, or not made exclusively from apple cider.

Cider Vinegar not the Exclusive Product of Pure Apple Juice, 5 Samples.

Acid (Per Cent.).	Solids (Per Cent.).	Ash (Per Cent.).	Polarization (200 mm. Ventzke).	Malic Acid Tests.		Color.
				Lead Acetate.	Calcium Chloride.	
5.04	3.05	-	+6.2	Positive, .	Positive, .	-
4.86	2.62	.14	+8.9	Positive, .	Negative, .	Caramel.
4.86	1.32	.28	—0.7	Negative, .	Negative, .	-
4.81	1.92	-	+3.1	Negative, .	Negative, .	-
4.42	1.38	.16	—0.8	Negative, .	Negative, .	Caramel.

Canned Goods.

Sixty-nine samples were examined, 6 of which were found to be not of good standard quality. Among the articles of this class examined were the following: beans, peas, corn, succotash, baked beans, mixed vegetables, pears, gage plums, blueberries, raspberries, peaches, strawberries, bacon, salmon, shrimp, mince meat; and the following soups: mock turtle, oxtail, consommé, chicken, mulligatawny.

Most of these were found to be of good standard quality, with the exception of the canned peas. The following brands of peas were found to be greened with copper. The product of Jules Dupont came under the variety known as soaked goods.

Published Results of Analyses of Canned Goods.

Variety.	Brand.	Manufacturer or Wholesaler.	Results of Analysis.
Peas, . .	Petits Pois, Extra Fins, .	Tisserand & Fils, . . .	Greened with copper.
Peas, . .	Petits Pois, Moyens, . .	Haskell Adams & Co., Boston,	Greened with copper.
Peas, . .	Petits Pois, Verts, . .	Nabob, Bordeaux, France, .	Greened with copper.
Peas, . .	Petits Pois, . . .	Alphonse Pinaud, Paris, .	Greened with copper.
Peas, . .	Petits Pois, . . .	Jules Dupont, ...	Greened with copper.

Miscellaneous Food.

One hundred and fifty-three samples of food not included in the classes hitherto mentioned were examined, 59 of which were found to be adulterated. Among the pure samples were included: beef extract, beer (2 samples), celery salt (2 samples), chewing gum, codfish, cooking oil, dried beef, evaporated apple (4 samples), flaxseed meal, grape juice, horseradish (2 samples), "jelly powder" (2 samples), milk powder, mince meat (4 samples), pastry spice, peanut butter (7 samples), pop corn cake, sage, sugar (2 samples), tripe, vegetable gluten.

The following miscellaneous foods examined call for more or less comment: —

Baking Powder. — Fifteen samples were examined, all of which were found to conform to the statute requiring the list of ingredients present.

Baking Soda. — Nine samples were examined, 1 of which was pronounced adulterated by reason of an excess of salt.

Cider. — Three samples of bottled sweet cider were analyzed, 2 of which were found to be preserved with benzoic acid. One of these bore no manufacturer's name; the other was labelled "Russet Cider," and was the product of the Copeland Farm Cider Mills of Milton.

Coffee Substitute. — Two samples were examined, one of which, labelled simply "Malt Coffee," evidently with the idea of conveying the impression that coffee was present, was condemned as containing no coffee.

Curry Powder. — Two samples were examined, one of which was found to contain rice starch as a filler.

Gluten Flour. — Two samples were analyzed, one of which, "Beardsley's Gluten Health Bread Flour. Entire Wheat," was found to be entire wheat flour with the normal percentage of starch, about 70 per cent., and the other sample was bulk goods, containing 63.7 per cent. of starch and 10.6 per cent. of protein. (See also "Vegetable Gluten" under "Drugs.")

Hamburg Steak. — Nineteen samples were analyzed, 17 of which were found to be preserved with a compound of sulphurous acid.

Jams and Jellies. — Thirty-five samples of these products were collected and analyzed, 24 of which were condemned as not conforming to the law. In most cases these products were the usual mixtures of apple stock and commercial glucose, either with or without varying proportions of cane sugar and of the genuine fruit which they purport to contain. The larger proportion were colored to conceal their inferior condition, and many were preserved with either benzoic or salicylic acid.

While many of these products have labels with the name and percentage of the ingredients, these labels are in many cases erroneous or misleading, or indistinct, so that they can by no means be considered in compliance with the law. Following is a list of jellies and jams published as adulterated during the year: —

Published Results of Analyses of Jams and Jellies.

CHARACTER OF SAMPLE.	Manufacturer.	Results of Analyses.
Raspberry preserve,	Logan, Johnson & Co., Boston,	Salicylic acid and a coal tar dye. No formula.
Raspberry jam,	Logan, Johnson & Co., Boston,	Benzoic acid; not in formula.
Raspberry jam,	Curtice Bros., Rochester, N. Y.,	Preserved with benzoic acid; amount of preservative not stated on formula.
Strawberry jam,	P. J. Ritter Conserve Company, Philadelphia, Pa. "We guarantee the original contents of this bottle to be a pure and wholesome article of food."	Benzoic acid.
Strawberry jam,	Ideal Preservative Company, Boston,	Benzoic acid; not in formula.

Ketchup. — Two samples only were examined, 1 of which was found preserved with benzoic acid.

Pickles. — Seven samples were analyzed, one of which was condemned as having been greened with copper salts.

" *N'egg.*" — This peculiar product, made by the Egg Substitute Company of Boston, was advertised by our Board many years ago, and it was thought had gone out of existence. It has again appeared upon the market during the present year.

It is claimed to be " the only genuine and nutritious substitute for eggs." It is put out in two boxes, one containing a white and the other a yellow powder, purporting to be " equivalent to the whites and yolks of one dozen eggs." As in the old days, the composition of the egg " white " was found to be nothing but tapioca starch ; while that of the egg " yolk " was also tapioca starch, colored with a coal tar dye.

Wild Cherry Juice. — The single sample of this preparation examined was found to contain 17.48 per cent. by volume of alcohol. It was the product of the Beach & Clarridge Company of Boston.

Summary of Food Statistics, exclusive of Milk.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.		Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Allspice, ...	154	5	159	31.4	Flavoring extracts — *Concluded.*				
Butter, ...	209	8	217	3.7	Peppermint, . .	1	1	2	50.0
Canned goods, . .	63	6	69	8.7	Vanilla, . . .	27	3	30	33.3
Cassia, ...	191	1	192	0.5	Ginger, . . .	212	4	216	1.9
Cayenne, ...	50	–	50	0.0	Honey, ...	38	4	42	9.5
Cheese, ...	57	3	60	5.0	Lard, ...	16	9	25	36.0
Clover, ...	150	16	166	9.6	Mace, ...	19	12	31	38.8
Cocoa, ...	14	7	21	33.3	Maple sugar, . .	12	6	18	33.3
Coffee, ...	86	4	90	4.4	Maple syrup, . .	18	28	46	60.9
Condensed milk, . .	80	12	92	13.0	Miscellaneous, . .	100	48	148	32.4
Confectionery, . .	33	1	34	29.4	Molasses, . . .	64	5	69	7.2
Cream of tartar, . .	264	6	270	1.7	Mustard, . . .	195	31	226	11.6
Flavoring extracts :—					Nutmeg, . . .	15	1	16	6.3
Almond, . .	20	4	24	16.6	Pepper, . . .	333	13	346	3.8
Banana, . . .	2	–	2	0.0	Tea, ...	50	–	50	0.0
Jamaica ginger, .	0	1	1	100.0	Vinegar, . . .	34	20	54	37.1
Lemon, . . .	13	19	32	59.4	Totals, . . .	2,521	278	2,799	9.9
Orange, . . .	1	0	1	0.0					

Drugs.

The drugs collected and examined during the year were from much the same suspicious classes as in past years, namely, those which experience has shown most liable to adulteration. A full summary of the quality of the drugs examined will be found on page 337.

Aqua Destillata. — All 9 of the samples of distilled water collected from drug stores were found to vary widely from the requirements of the Pharmacopœia.

In this age, when the question of purity of our drinking water is so prominently brought before us, it is difficult to see why samples of pure distilled water are so rarely dispensed from the average drug store. In most cases the results of our analysis indicate that ordinary tap water has been sold under the guise of aqua destillata.

One of the worst samples examined in years by our department contained 25.5 parts of residue per 100,000. This sample was purchased in a Chelsea drug store. Another sample bought in Boston was found with 11 parts of residue per 100,000, and a third in Lowell with 8 parts per 100,000.

Bismuthi Subnitras. — A sample of this drug sold by a Vineyard Haven druggist to a summer resident caused serious illness. On analysis in this laboratory the powder was found to consist entirely of tartar emetic, evidently substituted by mistake. A sample of bismuth subnitrate was immediately after purchased by one of our inspectors of the same druggist, and found to be pure.

Calx Chlorata. — None of the samples of chlorinated lime were found to be of standard quality. The Pharmacopœia calls for 35 per cent. of available chlorine.

The product of Joseph Brookman & Sons of Chicago, Ill., was found to stand 67 per cent. of the required strength; that of the Acme White Lead and Color Works of Detroit, Mich., stood only at 3 per cent. of the required strength, consisting largely of calcium carbonate; the Hudson Chloride of Lime, manufactured by A. Mendelson & Sons, Albany, N. Y., stood at 29 per cent. of the required strength.

Essential Oils. — A larger variety than usual of these preparations were examined, as will be seen by the summary, including oils of cloves, cassia, wintergreen, lemon and peppermint. The optical examinations of the essential oils furnish by far the most convenient means of judging of their purity. Of greatest importance is the refractometric examination, which is applicable in all cases.

For this purpose we use the Abbé refractometer, furnished with temperature-controlling apparatus. Some of the oils, like lemon and peppermint, that rotate the plane of polarized light, are examined by the polariscope. The specific gravity also serves as a helpful test in many cases. Much work remains to be done on essential oils of known purity, especially as regards their index of refraction, before perfectly satisfactory standards can be fixed.

The following constants were determined by H. C. Lythgoe on samples of essential oils obtained from Schimmel & Co., who were requested to furnish oils of known purity for the purpose of analysis for standards: —

Optical Constants of Some Essential Oils.

OIL.	Specific Gravity, 15°.	Polarization (100 mm. Degrees Ventzke).	n_D.				
			20°.	25°.	30°.	35°.	40°.
Peppermint,	0.9056	—79.7	1.4614	1.4593	1.4573	1.4553	1.4533
Peppermint,	0.9050	—77.8	1.4615	1.4594	1.4574	1.4554	1.4534
Sweet orange,	0.8510	272.8	1.4731	1.4708	1.4685	1.4662	1.4637
Bitter orange,	0.8532	266.6	1.4738	1.4715	1.4691	1.4667	1.4643
Citronella,	0.8996	—31.6	1.4813	1.4790	1.4768	1.4745	1.4722
Lemon grass,	0.9070	—10.0	1.4858	1.4836	1.4814	1.4792	1.4770
Spearmint,	0.9310	—126.4	1.4858	1.4836	1.4814	1.4792	1.4770
Cloves,	1.0502	—3.1	1.5313	1.5290	1.5268	1.5245	1.5222
Wintergreen (Betula),	1.1865	—0.1	1.5363	1.5340	1.5318	1.5295	1.5272
Wintergreen (Synthetic),	1.1865	0.0	1.5365	1.5342	1.5320	1.5297	1.5274
Cassia,	1.0666	0.7	1.5998	1.5973	1.5949	1.5925	1.5901
Cinnamon,	1.0395	—0.3	1.6029	1.6009	1.5988	1.5968	1.5948

Macis. — Two out of the 3 samples examined were found to consist wholly or in part of Bombay or wild mace.

Oleum Olivæ. — In 3 cases, samples of olive oil sold by druggists proved to consist almost entirely of cotton-seed oil.

Phenacetine. — Thirty-one samples were examined, 5 of which were found to be adulterated with acetanilid, and a number of court cases were brought for the sale of the adulterated article.

The method we most rely on to prove the presence of acetanilid consists in making a saturated aqueous solution of the sample in ice-cold water, and adding bromine water drop by drop to the clear solution in excess. If acetanilid is present, a white precipitate is formed on shaking. Another test consists in heating the sample with concentrated potassium hydroxide. If acetanilid is present, the odor of anilin is apparent, and on the addition of chloroform, the pungent odor of phenyl isocyanide is developed.

Sodii Boras. — Five samples out of the 17 examined consisted wholly or in part of sodium bicarbonate. The "Eclipse" brand of best refined borax, manufactured by M. J. and H. J. Meyer Company of New York, contained no borax whatever, being entirely sodium bicarbonate. The "Crescent" brand of C. L. Hirst & Co., New York, was largely sodium bicarbonate.

Spiritus Camphorœ. — Fifteen of the 22 samples examined were found to be low in strength. The following table shows the polarization and index of refraction of spirits of camphor of known strength, as made up in the laboratory with 95 per cent. alcohol. Lower refractions than those indicated in the table with this strength of alcohol would be suggestive of the presence of methyl alcohol.

Spirits of Camphor Standards.

Per Cent. of U. S. P. strength.	Polarization (200 mm. at 20°).	n_D at 35°.	Per Cent. of U. S. P. strength.	Polarization (200 mm. at 20°).	n_D at 35°.
0	0.0	1.3575	55	12.6	1.3623
5	1.0	1.3580	60	13.8	1.3638
10	2.1	1.3585	65	14.9	1.3644
15	3.2	1.3590	70	16.0	1.3650
20	4.4	1.3596	75	17.3	1.3655
25	5.4	1.3601	80	18.7	1.3660
30	6.5	1.3606	85	19.8	1.3665
35	7.7	1.3611	90	21.0	1.3670
40	8.9	1.3617	95	22.5	1.3675
45	10.2	1.3622	100	24.0	1.3680
50	11.4	1.3628			

Tinctura Iodi. — The usual high percentage of adulteration of this tincture was apparent, nearly 90 per cent. of those examined failing to conform to the Pharmacopœia. The quality of the samples collected is shown in the following statement: —

8 samples were between 90 and 95 per cent. of the United States pharmacopœial strength.
46 " " " 80 " 90 " " " " " "
45 " " " 70 " 80 " " " " " "
12 " " " 60 " 70 " " " " " "
5 " " " 50 " 60 " " " " " "
2 " " " 40 " 50 " " " " " "
2 " " " 30 " 40 " " " " " "
– " " " 20 " 30 " " " " " "
3 " " " 10 " 20 " " " " " "
1 " " " 5 " 10 " " " " " "

Two samples of tincture of iodine were found to contain wood alcohol. One was purchased of Harry F. Weir, 322 Blue Hill Avenue, Roxbury; the other of F. A. Smith of Braintree. For our method of detecting wood alco hol see page 342.

The worst sample of tincture of iodine examined in this department for some years was purchased of Ira P. Jefts, 2224 Washington Street, Roxbury. This contained about 5 per cent. of the required amount of iodine.

Miscellaneous Drugs. — Under this heading are included, besides unclassified drugs, a number of the pharmacopœial preparations where only one or two samples of each were collected.

Among those analyzed and found pure were the following: aristol (4 samples), cera alba, epsom salts, oleum anisi, potassii bitartras, pulvis effervescens compositus, pulvis ipecacuanhæ et opii (3 samples), quinine pills (12 samples), sapo, sulphonal, tinctura capsici, tinctura zingiberis (2 samples), trional.

Samples classed as adulterated or below standard were the following: —

Cure for Alcoholism. — Manufactured by B. M. Wooley of Atlanta, Ga., was found to contain morphine.

Liquozone. — "Simply liquid oxygen," a product of the Liquozone Company of Chicago, was found to be a solution of 1.35 per cent. of sulphurous and 1.08 per cent. of sulphuric acid in water.

Opium Cure. — This product, put out by the St. James Society, 1183 Broadway, New York, was found to contain in 100 cubic centimeters .028 gram of caffeine and .085 gram of morphine.

Paw-Paw. — Munyon's Paw-Paw, manufactured by the Munyon Remedy Company of Philadelphia, and claiming to "do away with both the necessity and desire for beer, wine and whiskey," was found to contain 29.51 per cent. of alcohol by volume. It was also found not to contain any of the starch-converting enzymes of paw-paw.

Spiritus Gaultheriæ. — One sample was examined containing insufficient oil of wintergreen, and colored red with a coal tar dye. This was purchased in a Newburyport drug store.

Vegetable Gluten. — "Pure vegetable gluten," put out by the T. Metcalf Company of Boston, was found to be virtually whole wheat flour, and contained 63 per cent. of starch and 10.9 per cent. of protein.

Vinum Album and Vinum Rubrum. — One sample of each was examined, both below the standard.

Summary of Drug Statistics.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Æther,	1	2	3	66.6
Alcohol,	3	3	6	50.0
Aqua ammoniæ fortior,	2	9	11	81.8
Aqua destillata,	–	9	9	100.0
Calx chlorata,	–	9	9	100.0
Capsicum,	51	4	55	7.3
Caryophyllus,	8	–	8	0.0
Chloroformum,	5	1	6	16.6
Cinnamomum cassia,	6	–	6	0.0

Summary of Drug Statistics — Concluded.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Extractum glycyrrhizæ,	2	16	18	88.8
Extractum zingiberis fluidum,	5	0	5	0.0
Ferri et quininæ citras,	12	2	14	64.3
Ferrum reductum,	9	9	18	50.0
Glycerinum,	88	5	93	5.4
Macis,	1	2	3	66.6
Magnesii sulphas,	2	1	3	33.3
Miscellaneous,	45	16	61	26.2
Oleum caryophylli,	2	1	3	33.3
Oleum cinnamomi,	3	4	7	57.1
Oleum gaultheriæ,	3	–	3	0.0
Oleum limonis,	5	30	35	12.0
Oleum menthæ piperitæ,	2	1	3	33.3
Oleum morrhuæ,	22	7	29	24.2
Oleum olivæ,	27	3	30	10.0
Oleum ricini,	35	2	37	5.4
Opii pulvis,	1	1	2	50.0
Phenacetine,	26	5	31	16.1
Pulvis glycyrrhizæ compositus,	17	–	17	0.0
Quininæ sulphas,	3	–	3	0.0
Sinapis alba,	4	–	4	0.0
Sodii benzoas,	16	–	16	0.0
Sodii boras,	12	5	17	29.3
Sodii iodidum,	6	4	10	40.0
Sodii phosphas,	31	1	32	3.1
Spiritus ætheris nitrosi,	–	2	2	100.0
Spiritus camphoræ,	7	15	22	68.2
Spiritus frumenti,	–	7	7	100.0
Spiritus menthæ piperitæ,	3	–	3	0.0
Spiritus myrciæ,	12	–	12	0.0
Sulphur lotum,	2	10	12	83.3
Sulphur præcipitatum,	2	11	13	84.6
Sulphur sublimatum,	8	–	8	0.0
Syrupus,	–	3	3	100.0
Tinctura iodi,	15	128	143	89.5
Tinctura opii,	1	1	2	50.0
Tinctura opii camphorata,	5	–	5	0.0
Zingiber,	16	–	16	0.0
Totals,	526	329	855	38.5

Summary of Food and Drug Statistics for Year ending Sept. 30, 1904.

	Genuine.	Adulterated.	Total.	Per Cent. Adulterated.
Milk,	3,064	1,627	4,691	34.6
Food, exclusive of milk,	2,521	278	2,799	9.9
Drugs,	526	329	855	38.5
Totals,	6,111	2,234	8,345	26.7

INSPECTION OF LIQUORS.

During the year ending Dec. 31, 1904, 238 samples of liquor were sent in for analysis by chiefs of police and other officers, in accordance with chapter 110 of the Acts of 1902. These samples came from 11 cities and 18 towns, the general character of the work done being summarized in the following table: —

Summary of Liquor Statistics.

	Number of Samples of Wine.	Number of Samples of Cider.	Number of Samples of Beer.	Number of Samples of Whiskey.	Number of Miscellaneous Samples.
Arlington,	–	1	–	–	–
Attleborough,	–	1	2	–	7
Avon,	–	2	–	–	–
Ayer,	–	–	1	–	–
Boston,	2	–	6	60	–
Brockton,	–	2	–	–	4
Cambridge,	1	–	2	–	1
Clinton,	2	11	15	–	–
Fall River,	–	–	1	–	–
Fitchburg,	5	1	8	–	2
Franklin,	–	–	7	–	–
Holliston,	–	–	4	5	–
Hyde Park,	–	1	–	–	–
Leominster,	6	1	1	5	–
Lowell,	–	–	3	–	–
Melrose,	–	2	–	–	–
Newton,	–	–	1	–	1
Norwood,	1	–	3	–	–
Peabody,	–	7	–	–	–
Pittsfield,	1	–	–	–	–
Quincy,	–	1	–	–	–
Randolph,	–	2	1	–	–
Revere,	–	–	14	–	–
Salem,	–	2	11	–	–
Swansea,	–	–	1	–	–
Wakefield,	5	3	–	–	1
Wareham,	3	–	–	–	2
Wellesley,	–	2	–	–	–
Winchendon,	–	2	–	–	–
Totals,	26	41	81	70	18

Deducting from the total the samples of whiskey, which were not sent in as a rule for purposes of prosecution, but because of the supposed existence of harmful adulterants, of the 173 samples of liquors remaining, 129, or about 75 per cent., were sold in no-license towns, and contained, on analysis, more than 1 per cent. of alcohol. The larger proportion of these were prosecuted; just how many, the analyst has no means of ascertaining, because in the larger number of these cases the analyst's certificate of analysis is accepted as evidence, and he is not notified of the disposition of the case. This is not always true, however, and the analyst has been summoned into court during the year on cases brought for prosecution for liquor seized in the following places: Attleborough, Boston, Brockton, Clinton, Revere, Salem and Wakefield. Besides these, a number of appealed cases requiring personal attendance were brought in the superior courts of Norfolk, Plymouth and Suffolk counties.

Among the miscellaneous liquors examined were 7 samples of Jamaica ginger high in alcohol, sold as a beverage; 1 sample of essence of peppermint, also sold as a beverage, containing 60 per cent. of alcohol; 4 samples of rectified alcohol, ranging from 50 to 80 per cent. by volume; and a peculiar sample of "mixed liquors," seized in Cambridge. This latter sample was found in a kitchen bar-room, and at the time of the raid, the owner of the liquor, surprised by the advent of the officers, threw the bottle of whiskey into a pot containing corned beef and cabbage boiling upon the stove. The bottle naturally broke, and the resulting liquor that the officers seized and brought in for analysis was found to contain 5.78 per cent. of alcohol.

The purpose of the act which authorizes the Board of Health to analyze these liquors has been solely to establish the percentage of alcohol, as determining whether or not a liquor may be sold in a no-license locality.

A number of city and town authorities, filled with the popular belief that adulterated liquors contain poisonous ingredients, the effect of which was to greatly increase intemperance far in excess of that caused by pure liquor, have requested analyses for such poisons.

Highest authorities are agreed that nothing in whiskey exercises so marked toxic effects as the alcohols which they naturally contain; that there are no authentic instances on record of the presence in whiskies of substances more poisonous than the alcohols; that, while most of the whiskies are adulterated, the chief adulterants are water and sugar, with the result that as a matter of fact those liquors, weak in alcohol, are less potent from a temperance stand-point than are the pure liquors conforming to the standard of the Pharmacopœia.

A large number of samples of whiskey have been tested in this laboratory for wood alcohol, and in no case has this adulterant been found present. In this connection, 60 samples of the cheapest whiskey which the saloons of Boston could supply were sent in, by order of the police authorities; and, on account of the interesting nature and source of these liquors, an exception was made in this case, and a more complete analysis than usual of these samples was made.

Of the samples examined, all but 2 failed to conform to the required standard of the Pharmacopœia in amount of alcohol (50 to 58 per cent. by volume). As regards their content in alcohol, the liquors stood as follows: —

Samples containing from 50 to 55 per cent. alcohol,	2
Samples containing from 45 to 50 per cent. alcohol,	14
Samples containing from 40 to 45 per cent. alcohol,	40
Samples containing from 35 to 40 per cent. alcohol,	2
Samples containing from 30 to 35 per cent. alcohol,	1
Samples containing from 25 to 30 per cent. alcohol,	1
	60

Most of these liquors were found to be adulterated, but the chief adulterants were water and sugar, and no poisonous substances foreign to whiskey were found. In fact, a large proportion of the liquors were found to be of the so-called "blended" or "rectified" variety, made of cologne spirit colored with caramel, often watered, and containing in some cases such artificial fruit essences as œnanthic and pelargonic ethers, added for flavor. The "rectified" variety of whiskey often contains no fusel oil. Several samples contained raw or unaged whiskey, with notable traces of the fusel oil which exists in nearly all pure whiskey, even when aged. In fact, nothing was found in any of the samples more harmful than the alcohols which are found in the purest whiskey; and, as shown above, most of the samples were weak in alcohol. Every sample was carefully tested for the presence of wood alcohol, and no traces of this poisonous substance were found.

Respectfully submitted,

ALBERT E. LEACH,
Analyst.

A METHOD FOR THE DETECTION AND DETERMINATION OF METHYL ALCOHOL IN ALCOHOLIC SOLUTIONS.

By ALBERT E. LEACH and HERMANN C. LYTHGOE.

PRELIMINARY PAPER.

The use of wood alcohol in various preparations which come within the domain of the public analyst for examination is apparently on the increase. In Michigan, out of 160 samples of lemon extract examined during 1904, 56, or 35 per cent., were found to contain methyl alcohol in varying amounts. Besides these, methyl alcohol was found in Michigan in vanilla extract, wintergreen, peppermint, orange, almond, and various artificial fruit extracts. These, however, were for the most part put up by local Western manufacturers, and were brands not found on sale in Massachusetts.

In our own State, while we have found methyl alcohol in various pharmaceutical preparations for external use, such, for example, as tincture of iodine, we have found it in only two instances in food, viz., in orange and lemon extracts.

Existing methods for the detection of wood alcohol are, with one or two exceptions, unsatisfactory. Most of the older methods, such, for example, as the potassium permanganate test, depend upon the presence of acetone in the methyl alcohol. With the improved refining processes used at the present day, wood alcohol is readily obtainable free from more than traces of acetone. The most practical method hitherto used for the detection of methyl alcohol is that of Mulliken and Scudder,* which depends on the oxidation of the methyl alcohol in the sample to formaldehyde by the use of a red-hot spiral of copper wire, using the hydrochloric acid and milk test for the detection of the formaldehyde formed.

Methods for quantitative determination of wood alcohol are even more rare. Duprey† has suggested a method of concentrating the alcohol by repeated distillation, after which part of the final distillate is oxidized to acetic acid, the latter being titrated with alkali, while the alcohol is determined in the other portion of the distillate from the specific gravity. Both methods with pure ethyl alcohol should give concordant results, whereas in the presence of methyl alcohol, a lower result is obtained by the oxidation process.

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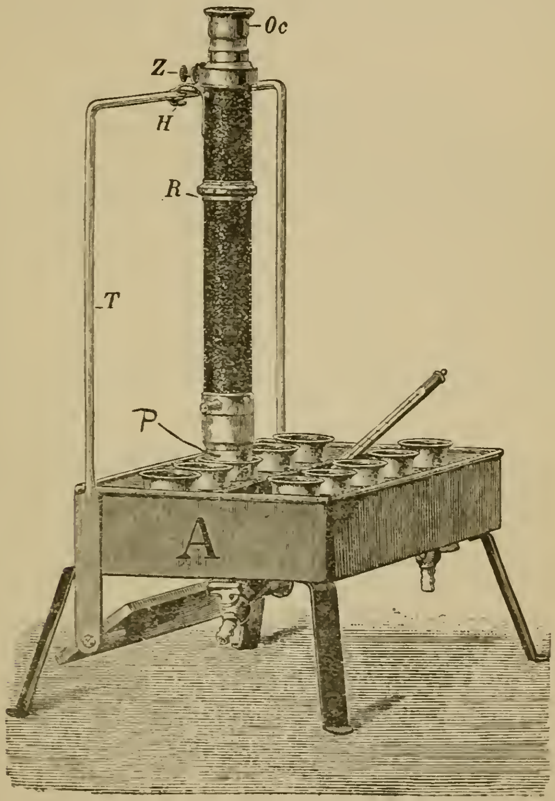
* American Chemical Journal, 24 (1900) p. 444.

† Analyst, I, 4.

The specific gravity of absolute methyl and ethyl alcohol is practically identical, and it is also true that when mixed with varying proportions of water, the specific gravity of both alcohols is so nearly the same (with the same proportions of water in each) that the same tables for computation of percentage of alcohol from the specific gravity may be used in one case as in the other.



One of the most important physical constants, however, which we have found to differ most widely in the two alcohols, is the index of refraction; and it is on this property that we base our method for the detection and determination of methyl alcohol.

We use for this purpose the immersion refractometer of Zeiss, as shown in the accompanying figure. This is the same instrument used by us for the detection of watered milk as described in our report for 1903.

To illustrate the wide difference in refraction between the two alcohols, the strongest commercial ethyl alcohol found on the market (the alcohol of the United States Pharmacopœia, which contains 91 per cent. of absolute alcohol by weight) gives a reading with the immersion refractometer of 98.3 at 20° C.; while the reading of methyl alcohol of 91 per cent. strength by weight is 14.9. Fifty per cent. ethyl alcohol by weight has a refraction on the immersion refractometer of 90.3; while the same strength (50 per cent.) of methyl alcohol refracts on the instrument at 39.8.

From this wide variation it is readily seen that there is no trouble in detecting even small amounts of methyl alcohol in mixtures. The following table shows the refractometer readings of varying strengths of both ethyl and methyl alcohol, all readings being made at 20°: —

Refraction of Ethyl and Methyl Alcohol.

[Scale of Zeiss immersion refractometer at 20° C.]

Per Cent. Alcohol by Weight.	Scale Reading.		Per Cent. Alcohol by Weight.	Scale Reading.		Per Cent. Alcohol by Weight.	Scale Reading.	
	Methyl Alcohol.	Ethyl Alcohol.		Methyl Alcohol.	Ethyl Alcohol.		Methyl Alcohol.	Ethyl Alcohol.
0	14.5	14.5	35	35.8	75.8	70	33.0	100.0
5	17.2	22.3	40	38.1	81.3	75	29.7	101.0
10	20.2	31.4	45	39.4	86.2	80	26.0	100.7
15	23.2	40.5	50	39.8	90.3	85	21.8	100.1
20	26.5	50.5	55	39.4	93.6	90	16.1	98.6
25	29.7	60.1	60	37.9	96.2	95	9.6	95.7
30	32.8	69.0	65	35.5	98.3	100	2.0	91.0

The difference in refraction between the two alcohols varies considerably for different strengths. In the case of methyl alcohol, starting at zero (or water containing no alcohol), at which the reading on the refractometer at 20° is 14.5, the refraction gradually increases with increasing strength of methyl alcohol up to about 50 per cent. of the latter by weight, where the refraction reaches its maximum, after which for higher strengths of methyl alcohol it drops quite rapidly, until at 100 per cent. the refraction is but 2.0.

In the case of ethyl alcohol, starting as before with pure water, and increasing the strength of the solution, the refraction increases quite rapidly up to solutions of about 75 per cent. strength, where it then drops slightly, but by no means to such an extent as in the case of wood alcohol. It will thus be seen that by far the widest variations in refraction between the two alcohols take place above 50 per cent. in strength.

The detection of wood alcohol by this method is comparatively simple, and consists simply in submitting to refraction by the immersion refractometer the distillate which one makes for the determination of ethyl alcohol in the regular manner in alcoholic beverages, essences, tinctures, extracts, or whatever may be the nature of the substance to be examined. If the refraction of the liquid shows the percentage of alcohol agreeing with that obtained from the specific gravity in the regular manner, it may safely be assumed that no methyl alcohol is present. If, however, an appreciable amount of methyl alcohol is present, the low refractometer reading will at once indicate the fact. Not only can methyl alcohol be thus readily detected, but the amount may be approximately calculated. Addition of methyl to ethyl alcohol decreases the refraction in direct proportion to the amount present. Hence the quantitative calculation may be readily made by interpolation, using the figures for pure ethyl and methyl alcohol of the same alcoholic strength as the sample. The degree of accuracy of this calculation varies with the strength of alcohol. For instance, with an alcoholic strength of 10 per cent. there is less exactness than at 50 per cent. strength, where 1 per cent. of methyl can be readily determined. From this point on the delicacy of the process naturally increases, until at 90 per cent. strength .1 per cent. of methyl alcohol may be determined with accuracy.

The following table shows the readings on the immersion refractometer at 20°, corresponding to each percentage of alcohol from 1 to 50 by weight, all readings being taken at exactly 20° C. This table will show at a glance whether a solution of given strength of alcohol, as determined from the specific gravity, contains ethyl or methyl alcohol, or is a mixture of the two.

Scale Reading on Zeiss Immersion Refractometer Corresponding to Each Per Cent. of Methyl and Ethyl Alcohol from 0 to 50 Per Cent. 20° C.

Per Cent. Alcohol by Weight.	Scale Reading.		Per Cent. Alcohol by Weight.	Scale Reading.		Per Cent. Alcohol by Weight.	Scale Reading.	
	Methyl Alcohol.	Ethyl Alcohol.		Methyl Alcohol.	Ethyl Alcohol.		Methyl Alcohol.	Ethyl Alcohol.
0	14.5	14.5	17	24.5	44.5	34	35.2	74.4
1	14.8	16.0	18	25.2	46.5	35	35.8	75.8
2	15.4	17.6	19	25.8	48.5	36	36.3	76.9
3	16.0	19.1	20	26.5	50.5	37	36.8	78.0
4	16.6	20.7	21	27.1	52.4	38	37.3	79.1
5	17.2	22.3	22	27.8	54.3	39	37.7	80.2
6	17.8	24.1	23	28.4	56.3	40	38.1	81.3
7	18.4	25.9	24	29.1	58.2	41	38.4	82.3
8	19.0	27.8	25	29.7	60.1	42	38.8	83.3
9	19.6	29.6	26	30.3	61.9	43	39.2	84.2
10	20.2	31.4	27	30.9	63.7	44	39.3	85.2
11	20.8	33.2	28	31.6	65.5	45	39.4	86.2
12	21.4	35.0	29	32.2	67.2	46	39.5	87.0
13	22.0	36.9	30	32.8	69.0	47	39.6	87.8
14	22.6	38.7	31	33.5	70.4	48	39.7	88.7
15	23.2	40.5	32	34.1	71.7	49	39.8	89.5
16	23.9	42.5	33	34.7	73.1	50	39.8	90.3

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN,

AND UPON BACTERIOLOGICAL DIAGNOSIS,

FOR THE

HALF YEAR ENDED SEPT. 30, 1904.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN

FOR THE

HALF-YEAR ENDED SEPT. 30, 1904.

The following report covers only the period from April 1, 1904, to Sept. 30, 1904, inclusive, the preceding six months having been included in the report for 1903. The change is made in order to secure uniformity in the periods covered by the reports of the various departments of the Board.

The production of diphtheria antitoxin has continued under the direction of Dr. Theobald Smith, at the Bussey Institute. The distribution has been conducted, as before, at the office of the Board.

The total number of packages issued by the Board during the nine years and six months ending with Sept. 30, 1904, was as follows: —

In 1895–1896 (year ending March 31),	1,724 bottles.
In 1896–1897 (year ending March 31),	3,219 bottles.
In 1897–1898 (year ending March 31),	4,668 bottles.
In 1898–1899 (year ending March 31),	12,491 bottles.
In 1899–1900 (year ending March 31),	31,997 bottles.*
In 1900–1901 (year ending March 31),	53,389 bottles.*
In 1901–1902 (year ending March 31),	40,211 bottles.*
In 1902–1903 (year ending March 31),	33,475 bottles.*
In 1903–1904 (year ending March 31),	41,133 bottles.*
During 6 months ending Sept. 30, 1904,	22,255 bottles.*
	244,562 bottles.

The reported cases of diphtheria in the State in the past six years (not deaths) were as follows: —

1899,	7,134	1902,	7,036
1900,	12,641	1903,	6,888
1901,	9,793	1904,	6,254

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* These numbers have reference to the actual number of bottles issued in packages of about 1,500 units each. In order to make this comparable with the figures of the first three years (1895–1898), a package of 1,000 units should be employed as a standard, so that the 200,205 bottles distributed during the preceding five years would be equivalent to about 300,000 of the strength at first employed.

The total number of deaths from this cause in 1904 was 699, which is the smallest number in any year since 1870.

Death-rate from Diphtheria in Massachusetts, Forty-four Years (1861–1904).

YEARS.	Death-rate from Diphtheria per 10,000 Population.	YEARS.	Death-rate from Diphtheria per 10,000 Population.	YEARS.	Death-rate from Diphtheria per 10,000 Population.	YEARS.	Death-rate from Diphtheria per 10,000 Population.	Estimated Death-rate without Use of Antitoxin.
1861, . .	8.9	1872, . .	4.9	1883, . .	8.6	1894, . .	7.4	–
1862, . .	9.2	1873, . .	4.7	1884, . .	8.6	1895, . .	7.1	10.6
1863, . .	18.2	1874, . .	5.7	1885, . .	7.8	1896, . .	6.6	12.4
1864, . .	15.9	1875, . .	11.4	1886, . .	7.8	1897, . .	5.5	11.0
1865, . .	9.3	1876, . .	19.6	1887, . .	7.9	1898, . .	2.6	5.6
1866, . .	6.4	1877, . .	18.7	1888, . .	8.7	1899, . .	3.7	9.0
1867, . .	4.5	1878, . .	14.6	1889, . .	10.2	1900, . .	5.3	14.7
1868, . .	5.7	1879, . .	13.1	1890, . .	7.3	1901, . .	4.1	10.9
1869, . .	5.4	1880, . .	13.4	1891, . .	5.3	1902, . .	3.0	7.4
1870, . .	4.6	1881, . .	13.1	1892, . .	6.2	1903, . .	2.8	7.4
1871, . .	5.0	1882, . .	9.6	1893, . .	5.8	1904, . .	2.3	7.0

During the six months covered by this report, 922 cases of diphtheria were treated with the antitoxin furnished by the Board. An account was kept of the amount employed in each case, with the exception of six in which the figures were not obtainable, and the results are shown in the following table: —

AMOUNT OF ANTITOXIN USED.	Number of Cases.	Deaths.	AMOUNT OF ANTITOXIN USED.	Number of Cases.	Deaths.
Less than 1,000 units, . .	2	–	4,000 to 5,000 units, . .	100	7
1,000 to 1,500 units, . .	–	–	5,000 to 10,000 units, . .	169	3
1,500 to 2,000 units, . .	45	5	10,000 to 15,000 units, . .	123	3
2,000 to 3,000 units, . .	19	2	15,000 to 20,000 units, . .	93	4
3,000 to 4,000 units, . .	50	1	20,000 and more units, .	315	41

In 216 reported cases the amount of antitoxin administered was less than 5,000 units in each case, and in 700 reported cases the dose was 5,000 units or more. Of these latter, in 531 cases the dose was not less than 10,000 units, and in 315 cases it was not less than 20,000 units.

The serum was distributed to local boards of health, to hospitals, and to practitioners in 113 cities and towns, 21 of which used more than 100 bottles each. The following table shows the distribution: —

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1904, to Sept. 30, 1904.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Adams,	30	Easton,	6
Agawam,	60	Everett,	30
Amesbury,	6	Fall River,	175
Andover,	60	Fitchburg,	37
Arlington,	12	Foxborough,	18
Attleborough,	6	Framingham,	18
Bedford,	12	Franklin,	9
Beverly,	28	Georgetown,	6
Blackstone,	30	Gloucester,	100
Boston: —		Haverhill,	36
Children's Hospital,	701	Holbrook,	12
City Hospital,	10,578	Holyoke,	100
General supply,	2,837	Hopedale,	24
Massachusetts Charitable Eye and Ear Infirmary.	12	Hopkinton,	18
Massachusetts General Hospital,	30	Hull,	10
Massachusetts Homœopathic Hospital.	375	Burrage Hospital,	3
Saint Mary's Infant Asylum,	25	Huntington,	6
Schoolship "Enterprise,"	12	Hyde Park,	36
West End Nursery,	60	Lawrence,	325
Braintree,	24	Lenox,	6
Brockton,	137	Leominster,	6
Brookline,	200	Lexington,	6
Cambridge,	350	Lowell,	600
Hospital,	75	Ludlow,	9
Canton,	6	Lynn,	501
Chelsea,	187	Malden,	87
Cheshire,	6	Mansfield,	6
Chicopee,	24	Marblehead,	73
Clinton,	72	Marlborough,	25
Cohasset,	12	Maynard,	3
Colrain,	4	Medfield,	9
Concord,	24	Medford,	96
Danvers,	36	Medway,	24
Dedham,	6	Melrose,	36
Dighton,	18	Methuen,	27
Duxbury,	4	Milford,	48

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1904, to Sept. 30, 1904 — Concluded.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Millis,	10	Somerville,	800
Milton,	42	Southbridge,	197
Natick,	6	Spencer,	12
New Bedford,	300	Springfield,	275
Newburyport,	49	Stoneham,	18
Newton,	162	Stoughton,	18
North Adams,	270	Swampscott,	6
North Andover,	18	Taunton,	36
North Brookfield,	3	Topsfield,	12
Northampton,	12	Townsend,	6
Norton,	2	Wakefield,	36
Norwell,	12	Waltham,	36
Norwood,	61	Warren,	6
Palmer,	12	Wayland,	6
Peabody,	12	West Springfield,	86
Pittsfield,	112	Westfield,	6
Plymouth,	12	Weymouth,	54
Quincy,	118	Whitinsville,	6
Randolph,	12	Whitman,	24
Reading,	36	Wilbraham,	6
Revere,	55	Wilmington,	12
Rockland,	18	Winchester,	24
Rockport,	37	Winthrop,	6
Rowley,	6	Woburn,	12
Salem,	182	Worcester,	375
Saugus,	25	Total,	22,255
Scituate,	6		

SUMMARY OBSERVATIONS UPON THE USE OF DIPHTHERIA ANTITOXIN IN MASSACHUSETTS DURING THE SIX MONTHS ENDED SEPT. 30, 1904.*

The whole number of returns of cases treated with diphtheria antitoxin furnished by the State Board of Health during the six months ended Sept. 30, 1904, to hospitals and to local boards of health for use in general practice, was 1,162. Of this number, 922 were returns of cases of diphtheria treated with antitoxin, and 240 were returns of other persons who had been exposed to infection and were treated for the purpose of immunization. These cases constitute only a fraction of those which were treated during these six months in the State with antitoxin furnished by the Board, since very many physicians failed to make returns to the Board.

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* The annual report for 1903 contains the data for the preceding six months.

Cases in which a Bacterial Examination was made.

The same methods of classification are continued in this report as were adopted in the reports of the previous nine years. The cases in which cultures were made are classified into positive and negative cases. Diagnostic examinations were made in 838 cases reported to the Board as having been treated with antitoxin, and of these, 808 proved to be genuine cases of diphtheria and 30 gave a negative result.

Positive Cases.

Of the 808 positive cases, or those in which a diagnosis of diphtheria was made by bacterial cultures from the throat of the patient, there were 751 recoveries and 55 deaths, or 6.8 per cent.; the results of the previous years having been, respectively, 13.7, 11.6, 8.2, 7.9, 11.4, 9.4, 10.1, 9.8 and 8.1 per cent. In 2 cases, whether recovery or death was not stated.

Sex. — The number of males was 354, and the deaths of these were 28, or 7.9 per cent. The number of females was 452, and the deaths of these were 27, or 6 per cent. In 2 cases the sex was not stated.

Ages. — The following table shows the cases and deaths by ages: —

Six Months ended Sept. 30, 1904.

AGE PERIODS.	Cases.	Deaths.	FATALITY (PER CENT.).	
			1904.	**1903.**
From 0 to 2 years,	57	9	15.8	25.8
From 2 to 5 years,	242	25	10.3	13.0
From 5 to 10 years,	280	16	5.7	5.9
Over 10 years,	206	5	2.4	2.4
Age unknown,	23	-	-	10.8
	808	55	6.8	8.1

Day of Illness when Antitoxin was first administered. — The following table presents the fatality, according to the day of illness on which the antitoxin was first administered: —

Day.	Cases.	Deaths.	Fatality (Per Cent.).									
			1904.*	**1903.**	**1902.**	**1901.**	**1900.**	**1899.**	**1898.**	**1897.**	**1896.**	**1895.**
First, . . .	74	2	2.7	3.3	9.8	9.5	6.4	9.8	8.2	8.0	0.0	0.0
Second, . .	218	5	2.3	4.0	6.7	6.7	6.0	5.6	1.8	8.9	9.5	9.7
Third, . .	188	16	8.5	6.2	5.5	9.4	7.7	12.8	6.2	7.0	8.3	8.7
Fourth, . .	111	9	8.1	12.1	12.7	12.5	11.3	14.1	13.2	3.0	22.7	15.4
Fifth, . . .	54	4	7.4	17.7	19.0	17.0	14.8	15.6	11.8	11.8	0.0	22.2
Sixth, . .	25	1	4.0	10.0	18.0	16.0	21.1	17.9	20.0	0.0	14.3	20.0
Seventh, . .	21	6	28.6	13.0	15.4	18.4	13.7	27.1	9.5	30.0	25.0	33.3†
Eighth and later,	48	4	8.3	8.5	17.8	18.5	16.8	14.7	10.4	13.6	16.6	–
Unknown, . .	69	8	–	–	–	–	–	–	–	–	–	–

* Six months only. † Seventh day and later.

The value of the foregoing table consists mainly in the definite statement of the fatality of cases according to the day of illness at which antitoxin treatment was begun. In general, it shows that the ratio of success in treatment depends largely upon the early date at which antitoxin is first administered. A fuller and more conclusive summary, embracing the whole period of nine years and six months, and containing greater numbers, may be found on a later page.

The cases in which antitoxin treatment was begun either upon the first, second or third days of illness constituted 59.4 per cent. of the whole number of positive cases reported to the Board to which antitoxin was administered during the six months under consideration.

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals, ...	724	49	6.8
In private practice, ...	84	6	7.1

Seasons of the Year. — The cases embraced in the foregoing enumeration occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1904.			**1904.**		
April, ...	144	8	August, ...	123	9
May, ...	184	15	September, . . .	126	8
June, ...	135	8	Not stated, . . .	1	–
July, ...	95	7		808	55

Negative Cases.

The reported cases in which a negative result was obtained were 30, and the deaths of these were 2, or 6.7 per cent.

Sex. — The males were 9, with 2 deaths, or 22.2 per cent.; and the females were 21, with no deaths.

Age. — The percentage of fatality at each of four age periods was as follows: 0 to 2 years, 7 cases, with no deaths; 2 to 5 years, 4 cases, with 1 death, or 25 per cent.; 5 to 10 years, 5 cases, with 1 death, or 20 per cent.; and all over 10 years, 14 cases, with no deaths.

SUMMARY OF THE NINE YEARS AND SIX MONTHS ENDED SEPT. 30, 1904.

Positive Cases treated with Antitoxin.

Whole number of positive cases for the nine years and six months, 13,753; deaths, 1,316; fatality, 9.6 per cent.

Sex. — The fatality by sexes was as follows: —

SEX.	Cases.	Deaths.	Fatality (Per Cent.).
Males,	6,454	658	10.2
Females,	7,205	642	8.9
Not stated,	94	16	–

Ages. — The fatality by ages was as follows: —

AGE PERIODS.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	1,434	318	22.2
2 to 5 years,	4,243	533	12.6
5 to 10 years,	4,063	283	7.0
Over 10 years,	3,561	125	3.5
Age unknown,	452	57	–

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals,	9,955	1,042	10.4*
In private practice,	3,786	274	7.2*
Not stated,	12	–	–

* This apparent difference in the fatality of hospital and of general or outside treatment with antitoxin is accounted for by the fact that a considerable number of severe and fatal cases of diphtheria, which were treated by physicians in general practice, were reported as having been transferred to a hospital after one or more days of home treatment, and died at the hospital.

Cases in which no Bacteriological Examination was made during the Six Months ended Sept. 30, 1904.

Reports were received of 84 cases where antitoxin was employed in which no cultures were taken. Of this number, 68, or 81 per cent., occurred in general practice, and the remainder were reported from hospitals. Of the whole number, 11 proved fatal, or 13.1 per cent.

Sex. — The number of males in this class was 36, and the deaths of these were 6, or 16.7 per cent. The number of females was 46, and the deaths of these were 5, or 10.9 per cent. The number of those whose sex was unknown or not stated was 2.

Age. — The following table presents the cases and fatality by ages among this class so far as observations were made: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
From 0 to 2 years, ...	5	2*	40.0
From 2 to 5 years, ...	28	8†	28.4
From 5 to 10 years, ...	27	–	–
Over 10 years, ...	24	1	4.2

* One case showed marked prostration.

† One case showed septic condition; 1 marked prostration, and 1 was moribund.

SEQUELÆ.

Temporary skin eruptions, usually of brief duration, are of very common occurrence after the administration of antitoxin. Frequently these eruptions are quite mild, and confined to a small area adjoining the place of injection, while occasional instances occur in which the eruption spreads throughout the entire surface of the body, or at least a portion of its area.

During the six months under consideration such eruptions or rashes are reported as occurring in 455 instances, or 49.3 per cent. of the whole number reported upon. Of this number, 95 per cent. were mild in character, and the remainder severe or extensive.

Albuminuria was reported in 38 instances, of which 35 were slight, or consisted of a trace only. The presence of albuminuria, however, has no significance as relating to the administration of antitoxin, since albuminuria is present, according to good authorities, in the majority of severe cases of diphtheria.*

OPERATIONS.

Tracheotomy, an operation which was once quite commonly resorted to in severe cases of laryngeal diphtheria, appears to have been largely supplanted by the more safe and simple operation of intubation. It is reported as having been performed 4 times, with 3 deaths.

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* Osler's "Practice of Medicine," second edition, page 115.

Intubation is reported as having been performed 61 times, with 15 deaths, or 24.6 per cent.

The different diseases which are met with as complications of diphtheria independently of the use of antitoxin appear to depend for their frequency largely upon the relative prevalence of these diseases throughout the State. In the six months, April 1 to Sept. 30, 1904, scarlet fever was reported as a complication in 3 instances and measles in 2. During the year 1903 the figures were: for scarlet fever, 28; and for measles, 10 instances. In most cases the complication adds to the severity of the cases and increases the fatality, but not to so great an extent as when pneumonia supervenes. Pneumonia and broncho-pneumonia were reported as complications in 10 cases, 6 of which proved fatal.

The most important lesson, repeated in former reports, to which the experience of each successive year adds emphasis, is the necessity of the early administration of antitoxin in each and every case.

IMMUNIZATION.

Returns of cases in which antitoxin had been used for the purpose of the immunization of persons who had been exposed to the infection of diphtheria were received in 240 cases. Of this number, 227 had been exposed to diphtheria, and had been immunized in the isolation wards of the Boston City Hospital, and chiefly in the scarlet-fever ward.

GENERAL SUMMARY, 1895-1904.

Positive cases treated in the nine years and six months ended Sept. 30, 1904, and reported to the State Board of Health,	13,753
Cases in which no bacteriological examination was made,	3,358
Total,	17,111*
Deaths of these,	1,742
Fatality (per cent.),	10.2

Sexes.

The number of males who were treated was †	7,965
The number of females who were treated was †	8,975
The number whose sex was not stated was †	171
Total,	17,111*
Deaths of males,	865
Fatality of males (per cent.),	10.9
Deaths of females,	852
Fatality of females (per cent.),	9.5
Deaths, sex not stated,	25

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* In this number (17,111), 1,593 cases in which a bacterial diagnosis showed negative results are not included, so that the whole number treated with antitoxin of which returns were made to the Board was 18,704.

† Except cases determined to be "negative."

The following table contains the results of those cases only which had been determined by a culture examination to be positive, with reference to the fatality of the disease in each group of cases, considered in relation to the stage of the disease when antitoxin was first administered.

Nothing can be more conclusive than the cumulative testimony of these figures, supported, as they are, by similar experience elsewhere, as to the importance of the earliest possible administration of antitoxin in the treatment of diphtheria. Each day's delay renders the liability to a fatal result greater.

The fatality of the cases which were treated with antitoxin very early in the course of the disease (that is, before the termination of forty-eight hours from its onset) was only 6.2* per cent., or 342 deaths in 5,483 cases; while that of the cases which were not thus treated until the sixth day or later was as high as 17 per cent., or nearly three times as great.

Day of Administration.

DAY.	Cases.	Deaths.	Fatality (Per Cent.).
First, ...	1,627	120	7.4
Second, ...	3,856	222	5.8
Third, ...	3,150	274	8.7
Fourth, ...	1,996	251	12.6
Fifth, ...	1,037	162	15.6
Sixth and later, ...	1,466	244	16.6

A considerable number of cases and deaths, in which the day of administration was not stated in the returns, is excluded from this table.

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* The sum of the experience of the first two days is expressed in this figure.

REPORT UPON DIPHTHERIA CULTURES EXAMINED DURING THE HALF YEAR ENDED SEPT. 30, 1904.

From April 1 to Sept. 30, 1904, 1,014 cultures were received from 98 towns and cities in the State. Of these cultures, 472 were for the purpose of diagnosis and 542 were for release from quarantine. The following table gives the number of cultures received from the different towns and cities and the results of the examinations: —

CITY OR TOWN.	Whole Number of Cultures examined.	CULTURES EXAMINED FOR DIAGNOSIS.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Acton,	1	1	-	-	-
Andover,	5	3	2	-	-
Arlington,	17	3	6	1	7
Athol,	1	-	1	-	-
Attleborough,	5	2	2	-	1
Avon,	1	-	1	-	-
Barnstable,	40	8	4	1	27
Bedford,	1	-	1	-	-
Belchertown,	2	-	1	1	-
Bernardston,	7	-	-	-	7
Beverly,	8	2	3	-	3
Blackstone,	2	-	2	-	-
Boston,	1	-	1	-	-
Braintree,	6	2	3	-	1
Cambridge,	1	-	1	-	-
Canton,	2	-	-	-	2
Chelsea,	33	5	10	1	17
Clinton,	18	7	5	-	6
Cohasset,	9	2	3	-	4
Colrain,	1	-	1	-	-
Concord,	3	-	3	-	-
Danvers,	6	2	3	-	1
Dedham,	1	-	1	-	-

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Duxbury,	6	–	6	–	–
East Bridgewater,	1	–	1	–	–
Easton,	8	1	1	1	5
Everett,	34	5	10	–	19
Foxborough,	8	1	7	–	–
Framingham,	4	–	4	–	–
Haverhill,	3	1	–	2	–
Hingham,	2	–	2	–	–
Holbrook,	11	1	10	–	–
Hopkinton,	3	1	1	–	1
Hubbardston,	1	1	–	–	–
Hull,	1	1	–	–	–
Hyde Park,	14	–	5	–	9
Ipswich,	1	–	–	–	1
Lancaster,	1	1	–	–	–
Lawrence,	8	1	7	–	–
Littleton,	4	–	–	–	4
Lynn,	12	–	2	–	10
Lynnfield,	1	–	1	–	–
Malden,	59	7	5	1	46
Mansfield,	5	1	2	2	–
Marblehead,	31	9	10	–	12
Marlborough,	15	1	6	–	8
Medfield,	6	1	1	–	4
Medford,	58	9	21	–	28
Medway,	4	1	1	–	2
Melrose,	10	1	3	–	6
Methuen,	2	1	1	–	–
Milford,	1	–	1	–	–
Millis,	1	–	1	–	–
Milton,	23	3	8	–	12
Natick,	8	3	2	–	3
Needham,	2	–	2	–	–
Newbury,	14	1	2	–	11
Newburyport,	18	5	12	–	1
New Marlborough,	1	–	1	–	–
North Adams,	158	26	7	–	125
North Attleborough,	2	–	2	–	–

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Norwell,	1	–	1	–	–
Norwood,	1	–	–	1	–
Peabody,	22	2	2	–	18
Plymouth,	2	1	1	–	–
Princeton,	2	–	2	–	–
Quincy,	17	4	8	–	5
Randolph,	1	1	–	–	–
Reading,	6	2	3	–	1
Revere,	11	2	9	–	–
Rockland,	20	3	2	–	15
Rockport,	2	–	2	–	–
Salem,	62	3	11	1	47
Saugus,	12	1	10	–	1
Scituate,	3	–	1	–	2
Shirley,	4	–	4	–	–
Southbridge,	2	–	2	–	–
Stoneham,	1	–	1	–	–
Stoughton,	11	1	–	–	10
Swampscott,	5	2	–	–	3
Topsfield,	13	2	1	–	10
Townsend,	3	2	–	–	1
Wakefield,	11	2	5	–	4
Walpole,	2	1	1	–	–
Wareham,	1	–	1	–	–
Warren,	6	1	2	–	3
Watertown,	12	–	4	–	8
Wayland,	2	–	2	–	–
Westport,	1	–	1	–	–
Weymouth,	13	2	4	1	6
Williamsburg,	2	–	–	–	2
Williamstown,	1	–	1	–	–
Wilmington,	2	1	1	–	–
Winchendon,	1	–	–	–	1
Winchester,	37	6	10	–	21
Winthrop,	2	–	2	–	–
Woburn,	7	–	6	–	1
Wrentham,	1	–	1	–	–
Total,	1,014	159	300	13	542

RELATION OF CLINICAL TO BACTERIOLOGICAL DIAGNOSIS.

Of the 472 cultures taken for diagnosis, the relation of the clinical to the bacteriological diagnosis is as follows: —

CLINICAL DIAGNOSIS.	BACTERIOLOGICAL DIAGNOSIS.		
	Positive.	Negative.	Doubtful.
Positive in 131 cases,	75	51	5
Negative in 113 cases,	19	91	3
Doubtful in 126 cases,	32	91	3
Not given in 102 cases,	33	67	2
Total,	159	300	13

Relation of Bacteriological Diagnosis to the Day of taking the Culture.

DAY OF DISEASE ON WHICH CULTURE WAS TAKEN.	BACTERIOLOGICAL DIAGNOSIS.		
	Positive.	Negative.	Doubtful.
First day,	8	17	–
Second day,	52	86	2
Third day,	37	76	2
Fourth day,	17	30	2
Fifth day,	9	23	2
Sixth day,	6	9	2
Seventh day,	6	10	–
Over seven days,	16	19	2
Not stated,	8	30	1
Total,	159	300	13

PERSISTENCE OF THE BACILLI OF DIPHTHERIA IN THE THROATS OF PATIENTS CONVALESCENT FROM DIPHTHERIA.

In 69 cases in which cultures were made at intervals of about a week, until a negative culture was obtained, the bacilli were last found on the days of the disease as indicated in the following table: —

TIME OF PERSISTENCE.	Number of Cases.	TIME OF PERSISTENCE.	Number of Cases.
8 days,	1	25 days,	2
9 days,	4	26 days,	5
10 days,	1	27 days,	1
11 days,	1	28 days,	1
12 days,	1	29 days,	2
13 days,	1	30 days,	2
14 days,	2	31 days,	4
15 days,	3	32 days,	2
16 days,	1	35 days,	2
17 days,	7	37 days,	1
18 days,	2	38 days,	1
19 days,	2	43 days,	2
20 days,	5	44 days,	1
21 days,	6	46 days,	1
22 days,	1	92 days,	2
23 days,	2		

SUMMARY.

The whole number of cultures examined since the bacteriological diagnosis of diphtheria was undertaken is as follows : —

In 1896–1897 (year ended March 31, 1897),	1,469
In 1897–1898 (year ended March 31, 1898),	2,204
In 1898–1899 (year ended March 31, 1899),	1,591
In 1899–1900 (year ended March 31, 1900),	3,258
In 1900–1901 (year ended March 31, 1901),	5,173
In 1901–1902 (year ended March 31, 1902),	4,119
In 1902–1903 (year ended March 31, 1903),	2,904
In 1903–1904 (year ended March 31, 1904),	3,632
From April 1 to Sept. 30, 1904,	1,014
Total,	25,364

Of these 25,364 cultures, 11,455 were made for the purpose of diagnosis and 13,909 for release from quarantine. Of the cultures made for diagnosis, 4,692, or about 41 per cent., were positive, 6,573 were negative, and 190 were doubtful.

REPORT UPON EXAMINATIONS OF SPUTUM AND OTHER MATERIAL SUSPECTED OF CONTAINING THE BACILLI OF TUBERCULOSIS.

From April 1 to Sept. 30, 1904, microscopical examination has been made of 494 lots of sputum and other material suspected of containing the bacilli of tuberculosis. This material has been received from 93 different cities and towns in the State. The following table gives the places from which the material has been received and the results of the microscopical examinations: —

City or Town.	Whole Number of Examinations.	Primary Examinations.			City or Town.	Whole Number of Examinations.	Primary Examinations.		
		Positive.	Negative.	Doubtful.			Positive.	Negative.	Doubtful.
Acton,	1	1	–	–	Concord,	3	2	1	–
Adams,	4	3	1	–	Concord, Massachusetts Reformatory.	13	5	8	–
Andover,	1	–	1	–	Danvers,	5	2	3	–
Arlington,	3	1	2	–	Dedham,	8	2	6	–
Ashland,	6	4	2	–	Edgartown,	1	–	1	–
Athol,	2	2	–	–	Everett,	18	10	8	–
Attleborough,	4	1	3	–	Fall River,	51	29	22	–
Barnstable,	1	1	–	–	Foxborough,	3	1	2	–
Bedford,	1	1	–	–	Framingham,	5	1	4	–
Berkley,	2	2	–	–	Franklin,	1	–	1	–
Beverly,	1	–	1	–	Freetown,	2	2	–	–
Blackstone,	2	–	1	1	Great Barrington,	5	1	3	1
Boston,	6	5	1	–	Greenfield,	1	1	–	–
Braintree,	6	4	2	–	Groton,	1	1	–	–
Bridgewater,	5	2	3	–	Haverhill,	1	1	–	–
Brookline,	1	–	1	–	Hingham,	3	–	3	–
Cambridge,	2	1	1	–	Holbrook,	4	2	2	–
Chatham,	1	1	–	–	Hyde Park,	12	3	9	–
Chelsea,	11	6	5	–	Ipswich,	5	2	3	–
Clinton,	4	2	2	–	Lawrence,	7	4	3	–

City or Town.	Whole Number of Examinations.	Primary Examinations. Positive.	Primary Examinations. Negative.	Primary Examinations. Doubtful.
Lexington,	6	2	4	–
Lincoln,	1	–	1	–
Littleton,	5	5	–	–
Lynn,	3	2	1	–
Malden,	11	8	3	–
Mansfield,	10	6	4	–
Marion,	1	1	–	–
Marlborough,	4	–	4	–
Medford,	6	1	5	–
Medway,	1	1	–	–
Melrose,	9	3	6	–
Middleton,	2	1	1	–
Milford,	2	–	2	–
Millis,	1	–	1	–
Milton,	2	1	1	–
Montague,	1	1	–	–
Natick,	10	3	7	–
Needham,	5	1	4	–
New Bedford,	1	1	–	–
Newburyport,	1	1	–	–
North Adams,	25	10	15	–
North Attleborough,	10	4	6	–
Northfield,	1	1	–	–
Norwood,	4	2	2	–
Peabody,	15	3	12	–
Plymouth,	3	–	3	–
Quincy,	31	9	22	–
Randolph,	1	–	1	–
Reading,	6	–	6	–
Revere,	8	3	5	–
Rockland,	6	4	2	–
Salem,	12	6	6	–
Scituate,	3	2	1	–
Shelburne,	3	1	2	–
Sherborn,	1	1	–	–
Shirley,	2	1	1	–
Spencer,	2	–	2	–
Swansea,	2	–	2	–
Taunton,	19	11	7	1
Topsfield,	2	1	1	–
Wakefield,	7	2	5	–
Walpole,	4	2	2	–
Warren,	1	–	1	–
Watertown,	1	–	1	–
Wellesley,	2	–	2	–
Westford,	3	1	2	–
Whitman,	2	1	1	–
Williamstown,	2	1	1	–
Winchendon,	2	–	2	–
Winchester,	6	1	5	–
Winthrop,	2	1	1	–
Woburn,	7	1	6	–
Worthington,	2	–	2	–
Wrentham,	2	–	2	–
Total,	494	213	278	3

Ages. — The relation of bacteriological diagnosis to age is shown in the following table: —

AGE PERIODS.	Number of Cases examined.	Positive.	Negative.	Doubtful.
From 0 to 10 years,	10	1	9	-
From 10 to 20 years,	75	39	36	-
From 20 to 30 years,	160	81	78	1
From 30 to 40 years,	105	45	59	1
From 40 to 50 years,	53	17	36	-
From 50 to 60 years,	40	12	28	-
From 60 to 70 years,	16	4	12	-
From 70 to 80 years,	11	3	8	-
Age not stated,	24	11	12	1
Total,	494	213	278	3

Sex. — The relation of bacteriological diagnosis to sex is shown in the following table: —

BACTERIOLOGICAL DIAGNOSIS.	Total.	Males.	Females.	Sex not stated.
Positive cases,	213	106	98	9
Negative cases,	278	132	141	5
Doubtful cases,	3	2	1	-
Total,	494	240	240	14

Clinical Diagnosis. — The relation of bacteriological to clinical diagnosis is as follows: —

CLINICAL DIAGNOSIS.	BACTERIOLOGICAL DIAGNOSIS.		
	Positive.	Negative.	Doubtful.
Positive in 188 cases,	103	83	2
Negative in 76 cases,	22	54	-
Doubtful in 109 cases,	34	75	-
Not given in 121 cases,	54	66	1
Total 494 cases,	213	278	3

Duration of Disease. — The relation of bacteriological diagnosis to the duration of the disease is shown below: —

Duration of Disease to the Time of Examination of Sputum.	Bacteriological Diagnosis.		
	Positive.	Negative.	Doubtful.
1 month or less,	18	25	-
1 to 2 months,	29	35	-
2 to 3 months,	20	29	-
3 to 6 months,	39	42	-
6 to 9 months,	12	6	-
9 to 12 months,	19	14	-
1 to 2 years,	18	14	2
Over 2 years,	8	20	1
Not given,	50	93	-
Total,	213	278	3

SUMMARY.

The number of specimens of sputum and other material examined for the bacilli of tuberculosis since the undertaking of these examinations is as follows: —

In 1896-1897 (year ended March 31, 1897),	124
In 1897-1898 (year ended March 31, 1898),	236
In 1898-1899 (year ended March 31, 1899),	414
In 1899-1900 (year ended March 31, 1900),	571
In 1900-1901 (year ended March 31, 1901),	746
In 1901-1902 (year ended March 31, 1902),	797
In 1902-1903 (year ended March 31, 1903),	928
In 1903-1904 (year ended March 31, 1904),	1,006
In 1904 (from April 1 to September 30),	494
Total,	5,316

Of these 5,316 specimens, 2,123, or 39.9 per cent., contained the bacilli of tuberculosis, in 3,135 specimens the bacilli were not found, and in 58 specimens no bacteriological diagnosis was made.

TYPHOID FEVER.

Widal, Agglutinative or Serum Test.

During the six months ended Sept. 30, 1904, 204 specimens of blood were subjected to the widal or agglutinative test for typhoid fever, the method employed being substantially the same as that described in the report for 1900. The dilution used corresponds to 1 part by weight of fluid blood to 20 of a bouillon culture of typhoid bacilli, or 1 part of blood serum to about 35 of culture fluid.

The blood specimens examined are given in the two following tables. In the first they are grouped according to towns. The whole number of specimens received is given, and divided into positive and negative, according to the outcome of the test. Sixty-one towns sent specimens to the laboratory, of which 46 were positive and 158 negative.

In the second table the results of the examination are arranged according to the day of the disease on which the blood was collected. From this table it will be seen that positive cases were most numerous after the sixth day of the disease. Since the agglutination-reaction may not appear until the second week of the disease, or even later, the blood of cases examined with negative result during the first week should be again examined in the second or third week.

Widal Test, April 1, 1904, to Sept. 30, 1904.

City or Town.	Number of Cases.	Positive.	Negative.	City or Town.	Number of Cases.	Positive.	Negative.
Arlington,	2	–	2	Lawrence,	2	1	1
Attleborough,	5	2	3	Leominster,	4	1	3
Barnstable,	1	–	1	Lincoln,	1	1	–
Bedford,	1	–	1	Lynn,	22	4	18
Beverly,	3	–	3	Malden,	1	–	1
Boston,	1	1	–	Marlborough,	4	2	2
Brewster,	2	–	2	Marshfield,	1	–	1
Cambridge,	3	–	3	Medford,	4	–	4
Concord,	3	–	3	Melrose,	4	–	4
Cottage City,	1	–	1	Milton,	2	1	1
Chelsea,	4	1	3	Natick,	1	–	1
Clinton,	1	–	1	Needham,	3	1	2
Danvers,	3	1	2	Newton,	2	–	2
Duxbury,	1	–	1	Newburyport,	13	2	11
Everett,	9	2	7	Peabody,	1	–	1
Foxborough,	1	1	–	Pepperell,	1	–	1
Haverhill,	2	1	1	Plymouth,	1	–	1
Hingham,	1	–	1	Randolph,	7	4	3
Holden,	4	1	3	Reading,	12	1	11
Hyde Park,	2	–	2	Revere,	3	2	1

Widal Test, April 1, 1904, to Sept. 30, 1904 — Concluded.

CITY OR TOWN.	Number of Cases.	Positive.	Negative.
Rockport,	2	–	2
Salem,	5	2	3
Scituate,	2	–	2
Somerville,	9	3	6
Southborough,	1	–	1
Stoughton,	1	–	1
Swampscott,	3	–	3
Taunton,	1	–	1
Topsfield,	1	–	1
Waltham,	4	2	2
Watertown,	13	2	11
Wayland,	1	–	1
Wellesley,	2	1	1
Westport,	2	–	2
Weymouth,	1	–	1
Williamstown,	4	2	2
Winchester,	8	3	5
Winthrop,	4	1	3
Woburn,	1	–	1
Total,	204	46	158

Widal Test, according to Stage of Disease, April 1, 1904, to Sept. 30, 1904.

APPROXIMATE NUMBER OF DAYS FROM BEGINNING OF DISEASE TO COLLECTION OF BLOOD.	NUMBER OF CASES.	
	Positive.	Negative.
3,	1	4
4,	2	2
5,	2	11
6,	2	5
7,	6	9
8,	5	12
9,	1	8
10,	2	11
11,	1	5
12,	1	7
13,	1	4
14,	6	13
15,	–	3
16,	1	1
17,	1	1
18,	2	3
19,	–	3
20,	–	3
21,	5	3
22,	–	2
23,	–	1
24,	–	1
26,	–	2
27,	–	1
28,	–	1
29,	–	1
30,	1	–
31,	–	1
32,	–	3
33,	–	2
34,	–	2
35,	–	2
37,	–	2
44,	1	–
53,	–	1
74,	–	1
84,	–	1
90,	–	1
Unknown,	5	25
Total,	46	158

MALARIA.

The number of blood films received by the laboratory during the six months ended Sept. 30, 1904, for microscopic diagnosis, was 24, of which only 3, or 12.5 per cent., showed the malaria parasite.

Malaria, April 1, 1904, to Sept. 30, 1904.

City or Town.	Number of Cases.	Positive.	Negative.
Arlington,	1	-	1
Concord,	3	-	3
Marshfield,	1	-	1
Melrose,	2	1	1
Quincy,	2	1	1
Reading,	1	-	1
Somerville,	2	-	2
Swampscott,	1	-	1
Uxbridge,	1	-	1
Westford,	1	-	1
Winchester,	9	1	8
Total,	24	3	21

STATISTICAL SUMMARIES

OF

DISEASE AND MORTALITY.

STATISTICAL SUMMARIES OF DISEASE AND MORTALITY.

The statistical information relating to disease and mortality which has been received by the Board during each year, either through the medium of voluntary returns or in consequence of legal requirements, has, in the recent reports of the Board, been presented under four different heads or groups. In the reports of 1902, 1903 and 1904 this series of statistics has been condensed as much as can be done consistently with a clear and intelligent method of presentation.

These summaries are defined as follows: —

I. *The Weekly Mortality Returns.* — These consist of the reports of deaths, which are made up weekly and are sent to the office of the State Board by the registration officials of cities and towns. They serve principally to show the seasonal prevalence of each of the chief infectious diseases, and the mortality of children under five years old, in weekly periods. Beginning with the year 1875, this series of statistics has been annually reported (see page 475 of report for that year), and was first published as a summary in the report of 1883.

II. *The Reports of Certain Infectious Diseases, — Diphtheria and Croup, Scarlet Fever, Typhoid Fever and Measles.* — These are obtained from the annual reports of local boards of health for the year 1904, which are forwarded to the State Board from cities and towns. By comparing the numbers of reported cases with the reported deaths, the mean fatality of each disease in the places from which the reports are made is obtained with a reasonable degree of accuracy. This summary was first presented in the report of 1891, page 878.

III. *Reports of Cities and Towns, made under the Provisions of Chapter 75, Section 52, of the Revised Laws.* — By this act each local board of health is required to report to the State Board every case of "disease dangerous to the public health" which is reported to the local board. A digest of these reports is presented in Summary No. III. This summary was first published in the report of 1893, page 639.

IV. *Annual Reports made under the Provisions of Chapter 75, Section 12, of the Revised Laws.* — The full reports of deaths occurring in each city and town having over 5,000 inhabitants comprise another series of returns, which are summarized in No. IV. The population of these cities and towns in 1904 constituted about 85 per cent. of the estimated total population of the State. These reports are made under the requirements of the following statute: —

> In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of the deaths in such town to the State Board of Health. The form of such reports shall be prescribed and furnished by the State Board of Health. (Revised Laws, chapter 75, section 12.)

This summary was first presented in the report of 1894.

NOTE. — A supply of the postal cards, necessary for the reporting of voluntary mortality returns such as are required for the data presented in section I. of the following summary, will be forwarded to the registration officers of any city or town who are willing to contribute the necessary information.

Postal cards are also sent to all boards of health in the State, for the purpose of aiding them to comply with the provisions of chapter 75, section 52, of the Revised Laws, relative to the reporting of diseases dangerous to the public health to the State Board immediately after reports of the same are received by the local board.

Annual blank forms are also sent to each local board of health in cities and towns having over 5,000 inhabitants, for the return of such information as is called for by the provisions of chapter 75, section 12, of the Revised Laws.

I.

The Weekly Mortality Returns.

In the following summary, the voluntary reports of deaths received at the close of each week from the city registrars, town clerks and boards of health of the cities and towns are epitomized for the year 1904. The chief value of this abstract consists in the fact that it presents a continuous history of the mortality from certain specified diseases from week to week throughout the year.

This weekly report has been published in the Boston Medical and Surgical Journal every week for a period of twenty-five years or more, and also as a publication of the Board, in a weekly bulletin, since and including 1883.

These returns are necessarily incomplete, since they are voluntary and consequently embrace the statistics of a portion only of the population, the reporting places being chiefly the cities and large towns.

The estimated population of the cities and towns contributing to these returns in 1904 was 2,135,416, or 68 per cent. of the estimated total population.

The following items are embraced in this summary: —

- Average height of barometer for each week.
- Mean maximum temperature.
- Mean minimum temperature.
- Rainfall, expressed in inches.
- Total deaths reported for each week.
- Deaths of children under five years.
- Deaths from consumption.
- Deaths from acute lung diseases.
- Deaths from typhoid fever.
- Deaths from diphtheria and croup.
- Deaths from scarlet fever.
- Deaths from measles.
- Deaths from diarrhœal diseases.
- Deaths from whooping-cough.
- Deaths from puerperal fever.
- Deaths from malarial fever.
- Deaths from erysipelas.
- Deaths from cerebro-spinal meningitis.

The following table contains a summary of the statistics compiled from these weekly returns of mortality: —

Summary for 1904.

1904.	Barometer.	Maximum Mean Thermometer for Each Week.	Minimum Mean Thermometer for Each Week.	Humidity.	Rainfall, in Inches.*	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet Fever.	Measles.	Diarrhœal Diseases.	Whooping-cough.	Puerperal Fever.	Malarial Fever.	Erysipelas.	Cerebro-spinal Meningitis.
Jan. 2,	29.98	25	9	71	–	666	177	52	108	7	7	4	1	7	3	2	–	3	3
9,	30.03	22	9	76	–	735	110	62	131	9	23	8	2	6	1	–	–	2	6
16,	29.78	36	23	81	–	700	227	74	134	6	17	6	4	11	3	–	–	3	3
23,	30.22	28	11	82	–	676	161	79	135	4	12	4	3	8	1	2	–	4	2
30,	30.22	29	14	69	4.39	657	179	61	112	5	10	4	2	10	2	–	–	4	6
Feb. 6,	29.99	32	13	66	–	615	149	64	106	1	8	6	2	3	1	1	–	4	5
13,	30.19	29	9	72	–	639	163	57	124	6	13	3	1	8	–	1	–	3	5
20,	30.09	26	11	73	–	693	191	63	123	4	18	2	7	13	–	–	–	4	5
27,	30.03	37	20	68	2.88	679	185	75	130	4	8	3	2	10	2	–	–	4	2
March 5,	30.27	35	21	75	–	700	189	78	131	10	12	2	14	7	1	–	–	6	3
12,	29.63	40	23	64	–	715	171	79	116	7	9	4	6	11	2	1	–	2	6
19,	29.97	38	26	66	–	730	197	72	134	5	13	6	10	5	1	1	–	3	5
26,	30.06	54	35	68	2.93	739	175	77	132	5	9	3	4	6	2	1	–	3	4
April 2,	30.15	43	34	71	–	724	197	76	119	5	8	3	8	12	2	1	–	3	6
9,	30.08	52	36	62	–	751	191	74	133	4	11	2	3	11	–	–	–	7	6
16,	29.83	51	36	62	–	641	176	67	114	1	9	3	6	13	4	–	–	7	4
23,	30.09	52	32	60	–	706	188	87	123	3	11	2	2	17	2	1	–	4	8
30,	29.94	57	43	83	7.10	672	192	72	100	5	7	1	8	15	3	1	–	5	2
May 7,	30.19	69	48	56	–	720	198	84	98	3	6	3	7	14	1	–	–	6	4
14,	30.00	66	52	84	–	631	176	76	94	4	7	1	3	9	2	3	–	4	2
21,	29.85	62	49	78	–	593	122	79	70	4	10	1	4	14	1	–	–	3	4
28,	29.95	79	58	63	3.24	491	119	54	61	6	7	–	2	13	–	–	–	2	3
June 4,	30.10	66	53	80	–	523	133	69	47	3	7	1	1	7	–	–	–	–	6
11,	30.05	68	52	86	–	518	141	56	52	6	7	1	3	10	1	–	–	–	4
18,	29.99	70	54	63	–	440	114	51	40	3	6	2	4	18	2	–	1	2	6
25,	29.96	82	61	65	3.96	548	152	67	43	4	14	–	5	25	–	–	–	1	3
July 2,	29.96	78	63	79	–	512	157	54	29	6	4	1	3	30	2	–	–	1	2
9,	30.10	75	64	77	–	500	126	55	26	2	7	1	2	33	–	–	–	–	5
16,	29.90	81	64	78	–	587	182	63	47	3	6	–	4	77	2	–	–	1	6
23,	29.91	79	65	67	–	651	262	63	31	7	5	–	4	118	3	–	–	–	3
30,	30.11	79	63	77	2.60	710	342	50	40	3	9	1	4	201	2	–	–	1	6
Aug. 6,	30.00	79	65	84	–	705	334	52	33	7	3	–	1	145	–	–	–	1	6
13,	30.15	74	61	71	–	726	317	49	22	6	5	–	1	187	3	–	–	–	5
20,	29.96	78	62	73	–	687	296	43	26	11	3	–	2	179	3	–	–	2	4
27	30.07	78	59	71	3.76	597	258	53	25	11	5	–	–	125	–	–	–	1	3

Sept. 3,	30.13	77	59	71	–	623	251	55	25	7	6	–	–	124	2	–	–	–	1
10,	30.14	70	55	77	–	603	221	60	33	6	6	2	–	98	5	2	–	–	3
17,	30.10	73	55	80	–	648	258	70	44	9	10	2	–	92	1	–	–	–	4
24,	30.23	67	48	68	4.68	641	249	46	51	8	9	2	–	74	2	1	–	–	5
Oct. 1,	29.83	66	55	77	–	629	210	73	43	8	10	–	–	69	1	2	1	–	5
8,	30.12	59	42	63	–	551	178	54	42	15	5	1	1	57	1	–	–	2	6
15,	30.12	59	43	81	–	524	154	56	51	12	15	–	–	33	–	–	–	–	4
22,	30.00	67	48	67	–	597	149	62	53	8	8	–	2	27	2	–	–	1	2
29,	30.17	55	38	67	1.86	550	156	51	58	7	17	–	–	19	1	–	–	2	4
Nov. 5,	30.13	50	35	63	–	558	157	44	70	8	12	1	1	22	–	–	–	–	2
12,	29.89	45	30	65	–	566	126	65	71	7	10	–	3	19	–	–	–	1	6
19,	30.07	43	28	66	–	561	134	47	77	8	13	1	–	13	–	–	–	1	–
26,	29.82	47	34	68	1.83	610	158	53	112	14	10	1	2	11	2	–	–	–	3
Dec. 3,	30.07	37	22	66	–	659	171	76	99	18	15	3	2	19	2	–	–	1	6
10,	29.91	27	19	69	–	605	137	56	89	11	11	3	1	1	–	1	–	4	6
17,	30.11	28	15	69	–	655	162	51	117	11	15	3	–	11	1	1	–	1	6
24,	29.98	39	20	71	–	617	146	62	101	4	13	3	1	11	2	–	–	3	5
31,	29.97	35	22	64	2.97	630	155	56	121	4	16	–	–	11	1	1	–	2	4
Totals,	–	–	–	–	42.20	33,404	9,819	3,324	4,246	345	517	100	148	2,089	75	23	2	114	225
Weekly average,	–	–	–	–	–	630	185	63	80	6.5	9.7	1.9	2.8	39.4	1.4	.4	.04	2.1	4.2
Rate per 1,000 deaths,	–	–	–	–	–	–	293.9	99.5	127.1	10.3	15.5	3.0	4.4	62.5	2.3	.69	.06	3.41	6.74
Rate per 1,000 population,	–	–	–	–	–	15.64	4.60	1.56	1.99	.16	.24	.05	.07	.98	.04	.01	.0009	.053	.11

Average reporting population, ... 2,135,416

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* Rainfall in inches. The figures in this column are given in months instead of by weeks.

Condensed Statistics, embracing the Total Deaths, Deaths under Five Years, and Deaths from Certain Causes in Reporting Cities and Towns of Massachusetts in 1904.

	Deaths.	Average Number of Deaths in Each Week.	Percentage of Total Mortality.	Death-rate per 1,000 of Reporting Population.
Total deaths,	33,404	630	100.00	15.64
Deaths under five years,	9,819	185	29.39	4.60
Deaths from consumption,	3,324	63	9.95	1.56
Deaths from acute lung diseases,	4,246	80	12.71	1.99
Deaths from typhoid fever,	345	6.5	1.03	0.16
Deaths from diphtheria and croup,	517	9.7	1.55	0.24
Deaths from scarlet fever,	100	1.9	0.30	0.05
Deaths from measles,	148	2.8	0.44	0.07
Deaths from diarrhœal diseases,	2,089	39.4	6.25	0.98
Deaths from whooping-cough,	75	1.4	0.23	0.04
Deaths from puerperal fever,	23	0.4	0.069	0.01
Deaths from malarial fever,	2	0.04	0.006	0.0009
Deaths from erysipelas,	114	2.1	0.341	0.053
Deaths from cerebro-spinal meningitis,	225	4.2	0.674	0.11

The usual observations upon the weekly mortality statistics are omitted, and the foregoing short table, containing the essential statistics, supplies their place. The omission is made because information of the same character is presented in a different form in Section IV. of these summaries. The chief difference consists in the fact that the information given in this section (I.) is entirely voluntary and is detailed by weeks, while that of Section IV. is required by statute, the data not being forwarded to the Board until after the close of the year. The population which furnishes the statistics presented in Section IV. is considerably larger than that embraced in Section I., but both populations consist of the more densely settled parts of the State.

METEOROLOGY.

The principal points of sanitary interest in the meteorology of Massachusetts for the year 1904 were the following: —

The mean temperature of the year in the State was 45.1° F.

The mean temperature of the summer months of June, July, August and September was as follows: June, 63.6°; July, 69.7°; August, 65.3°; September, 60.6°.

The annual rainfall was 42.2 inches, or a little below the average of a series of years.

II.

Fatality of Certain Diseases.

The following statement presents the statistics gathered from the published reports of local boards of health relative to the numbers of the cases and the deaths from each one of certain notifiable diseases. Its object is to present the fatality of these diseases (ratio of deaths to cases) from year to year. The complete statistics of reported cases are given in Section III.

The diseases embraced in this summary in 1904 are diphtheria, scarlet fever, typhoid fever and measles.

The tabular list of cities and towns is omitted in this report. The summary of the figures for 1904 is as follows: —

Reported cases of diphtheria and croup,	6,254
Registered deaths from diphtheria and croup in the same cities and towns,	577
Fatality (per cent.),	9.2

Reported cases of scarlet fever,	3,441
Registered deaths from scarlet fever in the same cities and towns,	109
Fatality (per cent.),	3.2

Reported cases of typhoid fever,	2,426
Registered deaths from typhoid fever in the same cities and towns,	410
Fatality (per cent.),	16.9

Reported cases of measles,	11,662
Registered deaths from measles in the same cities and towns,	163
Fatality (per cent.),	1.4

The following table presents the summary of these statistics for the fourteen years 1891–1904: —

Reported Cases of Infectious Diseases in Massachusetts.

Diphtheria and Croup.

[Pre-Antitoxin Period.]

	1891.	1892.	1893.	1894.	Total.
Reported cases,	2,444	3,033	2,919	4,936	13,332
Deaths,	575	891	926	1,376	3,768
Fatality (per cent.),	23.5	29.2	31.7	27.9	28.3

Diphtheria and Croup.

[Antitoxin Period.]

	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	Total 1895-1904.
Reported cases, . .	7,856	8,915	7,856	3,843	6,540	12,578	8,921	5,848	5,319	6,254	73,880
Deaths, ...	1,484	1,348	1,107	507	758	1,274	938	666	592	577	9,251
Fatality (per cent.), .	18.9	15.1	14.1	13.2	11.6	10.2	10.5	11.4	11.1	9.2	12.5

Scarlet Fever.

	1903.	1904.	Total 1891-1904.
Reported cases, ...	4,911	3,441	71,930
Deaths, ...	387	109	4,050
Fatality (per cent.), ...	7.8	3.2	5.6

Typhoid Fever.

Reported cases, ...	2,594	2,426	34,598
Deaths, ...	363	410	6,161
Fatality (per cent.), ...	14.0	16.9	17.8

Measles.

Reported cases, ...	8,166	11,662	109,629
Deaths, ...	149	163	1,436
Fatality (per cent.), ...	1.8	1.4	1.3

In the foregoing tables the statistics relating to diphtheria and croup have been arranged in two periods, which may properly be called the pre-antitoxin and the antitoxin periods, since antitoxin came into general use in the State about the beginning of the year 1895. The mean fatality in the former period (1891–1894) was 28.3 per cent. (ratio of deaths to cases), and in the latter period (1895–1904) it was 12.5 per cent., or less than half as large.

III.

Official Returns of Notified Diseases Dangerous to the Public Health, 1904.

The figures presented in the following summary are those of the official returns of diseases "dangerous to the public health," made to the State Board of Health during the year 1904, under the provisions of chapter 75 of the Revised Laws. In this act no disease is specified as being "dangerous to the public health" except smallpox. Hence the State Board deemed it necessary to indicate the diseases which should be included in the meaning of the term "dangerous to the public health." They are the following: smallpox, scarlet fever, measles, typhoid fever, diphtheria, membraneous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy, trichinosis.

The whole number of cases of infectious diseases reported to the Board in 1904, under the provisions of this act was 26,088, which were divided as follows: —

Reported cases of smallpox,	100
Reported cases of scarlet fever,	4,100
Reported cases of diphtheria and croup,	6,772
Reported cases of typhoid fever,	2,605
Reported cases of measles,	12,511
Total,	26,088

The summary for the eleven years and four months 1893–1904 is as follows: —

	Reported Cases of —					Total.
	Smallpox.	Scarlet Fever.	Diphtheria and Croup.	Typhoid Fever.	Measles.	
1893 (four months only),	35	2,914	1,109	1,525	1,503	7,086
1894,	181	6,731	4,178	2,372	2,133	15,595
1895,	1	6,194	7,806	2,438	4,868	21,307
1896,	5	3,801	8,515	2,637	6,362	21,320
1897,	18	5,495	7,613	2,104	12,695	27,925
1898,	10	3,667	3,980	2,196	4,478	14,331
1899,	105	5,349	7,134	2,776	12,355	27,719
1900,	104	6,396	12,641	2,967	10,507	32,615
1901,	773	4,356	9,793	2,689	9,398	27,009
1902,	2,314	4,613	7,036	2,721	17,249	33,933
1903,	422	5,877	6,888	2,955	9,430	25,572
1904,	100	4,100	6,772	2,605	12,511	26,088
Total,	4,068	59,493	83,465	29,985	103,489	280,500

By months these diseases were reported as follows: —

Cases of Infectious Diseases reported to the State Board of Health by Months in 1904.

MONTHS.	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.	MONTHS.	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
January, . .	5	604	794	148	1,363	August, . .	23	129	352	305	77
February, . .	5	544	548	111	2,365	September, .	46	172	523	437	47
March, . .	3	449	533	111	2,293	October, . .	3	294	716	450	135
April, . . .	1	426	524	119	1,965	November, . .	–	328	684	265	235
May, . . .	8	280	458	166	1,813	December, . .	–	465	687	209	436
June, . . .	3	237	555	114	1,198	Total, . .	100	4,100	6,772	2,605	12,511
July, . . .	3	172	398	170	584						

The following table is introduced for the purpose of facilitating the comparison of the seasonal prevalence of the diseases named in the table, in different years. By means of the method employed, the errors due to the difference in the length of the months are eliminated. The figures should be read as follows: for example, the mean daily number of reported cases of diphtheria reported throughout the year in 1904 was 18.5; of scarlet fever, 11.2; of typhoid fever, 7.1; and of measles, 34.2. During the month of January the mean daily number of reported cases of these diseases was, for diphtheria, 25.6; scarlet fever, 19.5; typhoid fever, 4.8; and for measles, 44.0 (see columns marked A).

Assuming a standard of 10 as a daily mean throughout the year for each disease, the ratios for January were as follows: diphtheria, 13.8; scarlet fever, 17.4; typhoid fever, 6.8; and measles, 12.9 (see columns marked B). So that for each 10 cases of diphtheria reported as a daily mean throughout the year 1904 there were 13.8 in January, 10.2 in February, 9.3 in March, etc.

From this table it appears that the maximum prevalence of diphtheria in 1904 was in January and the minimum in August. The prevalence in the last three months in the year was greater than that of the first three months. There has been in every one of the past ten years a decline in the prevalence of the disease in December, except in December, 1899.

The prevalence of scarlet fever was above the mean in January, February, March, April and December, and below it in the remaining months, the maximum occurring in January and the minimum in August. In the previous year the maximum was in May and the minimum in September.

Typhoid fever was, as usual, below the mean in the intensity of its prevalence in the first seven months of 1904, rising to a maximum in September.

In 1904, as in 1901, 1902 and 1903, the intensity of its prevalence in September and October was nearly equal.

The prevalence of measles was much above the mean in the first half of the year and below it in the last half, the maximum occurring in February and the minimum in September.

Certain Infectious Diseases. Seasonal Intensity of Prevalence.

Months.	Diphtheria.			Scarlet Fever.			Typhoid Fever.			Measles.		
	1904.		1903.	1904.		1903.	1904.		1903.	1904.		1903.
	A	B	B	A	B	B	A	B	B	A	B	B
	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.
January, .	25.6	13.8	11.0	19.5	17.4	12.9	4.8	6.8	7.8	44.0	12.9	15.9
February, .	18.9	10.2	10.4	18.8	16.8	12.3	3.8	5.4	5.9	81.6	23.9	18.1
March, . .	17.2	9.3	7.9	14.5	12.9	12.2	3.6	5.1	5.3	74.0	21.6	17.6
April, . .	17.5	9.5	6.8	14.2	12.7	11.1	4.0	5.6	4.4	65.5	19.2	14.9
May, . .	14.8	8.0	8.5	9.0	8.0	13.4	5.4	7.6	6.8	58.5	17.1	14.6
June, . .	18.5	10.0	8.0	7.9	7.1	12.7	3.8	5.4	7.5	39.9	11.7	11.6
July, . .	12.8	6.9	6.7	5.5	4.9	6.9	5.5	7.7	8.9	18.8	5.5	4.3
August, . .	11.4	6.2	6.9	4.2	3.8	5.5	9.8	13.8	17.7	2.5	0.7	1.9
September, .	17.4	9.4	7.6	5.7	5.1	5.0	14.6	20.6	16.1	1.6	0.5	0.9
October, . .	23.1	12.5	16.3	9.5	8.5	7.2	14.5	20.4	17.4	4.4	1.3	3.2
November, .	22.8	12.3	15.3	10.9	9.7	8.3	8.8	12.4	13.7	7.8	2.3	7.1
December, .	22.2	12.0	14.3	15.0	13.4	12.5	6.8	9.6	8.2	14.1	4.1	10.1
Mean, .	18.5	10.0	10.0	11.2	10.0	10.0	7.1	10.0	10.0	34.2	10.0	10.0

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Fifty-nine Cities and Towns during 1904.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Abington, . . .	–	17	3	–	4	Amherst, . .	–	1	2	–	16
Acton, . . .	–	8	3	1	27	Andover, . .	–	23	33	12	–
Acushnet, . .	–	2	1	–	–	Arlington, . .	–	75	21	7	31
Adams, . . .	3	3	12	10	–	Ashburnham, .	–	–	3	–	–
Agawam, . .	–	1	23	–	–	Ashfield, . .	–	–	–	1	–
Amesbury, . .	–	74	3	7	1	Ashland, . .	–	3	–	–	–

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Fifty-nine Cities and Towns during 1904— Continued.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Athol,	–	1	2	1	3	Clinton,	–	16	19	1	5
Attleborough,	–	17	16	5	30	Cohasset,	–	–	11	1	5
Auburn,	–	6	–	–	–	Colrain,	–	–	1	–	–
Avon,	–	2	–	–	44	Concord,	–	10	11	3	6
Ayer,	–	11	2	1	–	Dalton,	–	10	–	–	–
Barnstable,	–	4	7	4	510	Dana,	–	–	1	–	–
Barre,	–	7	1	–	5	Danvers,	–	9	5	–	1
Becket,	–	–	4	–	–	Dartmouth,	–	2	–	1	–
Bedford,	–	–	12	3	–	Dedham,	–	8	2	5	26
Bellingham,	–	2	2	–	–	Deerfield,	–	11	1	–	5
Belmont,	–	3	2	–	17	Dighton,	–	2	16	–	–
Berlin,	–	1	–	2	–	Douglas,	–	–	–	1	–
Bernardston,	–	–	5	–	–	Dracut,	–	3	15	–	2
Beverly,	1	10	22	21	8	Dudley,	–	–	1	2	–
Billerica,	–	1	14	–	–	Dunstable,	–	2	–	–	–
Blackstone,	–	–	3	–	–	Duxbury,	–	3	–	1	45
Boston,	–	1,026	2,596	888	4,488	East Bridgewater,	–	2	–	1	129
Boxborough,	–	1	–	–	–	Easthampton,	–	–	3	11	–
Boylston,	–	1	–	–	–	East Longmeadow,	–	3	–	–	–
Braintree,	–	30	5	5	160	Easton,	–	–	3	2	–
Brewster,	–	–	–	1	–	Essex,	–	2	–	1	4
Bridgewater,	–	–	–	1	37	Everett,	–	69	46	22	134
Brockton,	–	70	33	43	1,771	Fairhaven,	–	8	2	3	2
Brookfield,	–	1	3	1	–	Fall River,	–	98	117	79	1
Brookline,	–	29	35	15	108	Falmouth,	–	1	–	–	4
Cambridge,	–	137	339	139	474	Fitchburg,	3	12	12	12	31
Canton,	–	–	2	3	18	Foxborough,	–	5	3	6	–
Carlisle,	–	3	–	–	1	Framingham,	–	15	11	1	3
Charlton,	–	–	–	2	–	Franklin,	–	6	13	–	–
Chatham,	–	1	–	–	–	Freetown,	–	3	1	–	–
Chelmsford,	–	18	24	2	14	Gardner,	1	4	32	3	–
Chelsea,	–	50	80	41	228	Georgetown,	–	3	3	–	–
Cheshire,	–	–	13	1	–	Gill,	–	2	–	–	7
Chester,	–	–	1	11	–	Gloucester,	–	16	78	7	7
Chicopee,	–	33	33	12	5	Grafton,	–	2	–	–	–

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Fifty-nine Cities and Towns during 1904 — Continued.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Granville, . .	–	–	–	–	6	Lowell, . . .	4	131	283	47	433
Great Barrington,	–	1	9	–	–	Ludlow, . .	–	2	–	–	–
Greenfield, . .	–	33	4	5	7	Lynn, . . .	–	73	139	81	70
Groton, . . .	–	1	–	–	–	Malden, . .	–	65	88	61	549
Groveland, . .	–	9	1	3	–	Manchester, . .	–	1	1	1	–
Hadley, . .	–	–	1	–	–	Mansfield, . .	–	42	3	6	2
Hanover, . .	–	5	3	3	25	Marblehead, . .	–	23	16	4	8
Hardwick, . .	–	16	6	5	2	Marlborough, .	–	27	29	6	67
Harvard, . .	–	14	–	5	–	Marshfield, . .	–	1	–	–	8
Harwich, . .	–	5	–	–	12	Mashpee, . .	–	–	–	1	–
Hatfield, . .	–	1	2	1	3	Mattapoisett, .	–	1	–	–	3
Haverhill, . .	–	22	37	59	305	Maynard, . .	–	3	1	2	–
Hingham, . .	–	6	3	–	–	Medfield, . .	–	1	3	–	1
Holbrook, . .	–	8	4	2	23	Medford, . .	–	40	35	23	147
Holden, . .	–	18	1	10	3	Medway, . .	–	5	1	–	3
Holliston, . .	–	3	3	–	–	Melrose, . .	–	18	13	7	68
Holyoke, . .	–	20	119	21	33	Mendon, . .	–	1	3	–	–
Hopedale, . .	–	6	4	1	–	Merrimac, . .	–	4	4	–	1
Hopkinton, . .	–	–	4	–	2	Methuen, . .	–	34	19	10	6
Hubbardston, .	–	8	–	2	–	Middleborough, .	–	8	1	3	–
Hudson, . .	–	2	7	16	–	Middleton, . .	–	1	1	–	–
Huntington, . .	–	–	1	–	–	Milford, . .	1	18	13	4	1
Hyde Park, . .	–	21	12	3	55	Millbury, . .	–	12	1	–	–
Ipswich, . .	–	2	7	19	23	Millis, . . .	–	–	1	–	–
Lakeville, . .	–	1	–	–	–	Milton, . . .	–	13	20	9	64
Lancaster, . .	–	1	3	–	–	Monroe, . .	2	1	4	–	–
Lawrence, . .	10	58	102	63	198	Monson, . .	–	1	–	–	3
Lee, . . .	4	9	–	–	–	Montague, . .	–	1	1	6	–
Leicester, . .	–	1	–	–	–	Nahant, . . .	–	–	–	1	–
Leominster, . .	5	9	3	5	2	Natick, . . .	–	1	–	–	–
Lexington, . .	–	5	6	–	4	Needham, . .	–	6	2	2	9
Leyden, . .	–	–	–	–	3	New Bedford, .	–	55	73	55	37
Lincoln, . .	–	2	–	1	–	Newbury, . .	–	–	6	2	1
Littleton, . .	–	11	–	–	1	Newburyport, .	–	13	28	21	142
Longmeadow, .	–	8	2	–	–	Newton, . .	–	101	80	38	80

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Fifty-nine Cities and Towns during 1904 — Continued.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
North Adams, .	61	30	141	24	193	Salisbury, . .	–	–	–	4	6
Northampton, .	–	3	5	16	117	Sandisfield, . .	–	–	1	–	–
North Andover, .	–	3	4	3	6	Sandwich, . .	–	–	–	–	72
No. Attleborough,	–	2	–	–	2	Saugus, . . .	–	6	26	2	22
Northborough, .	–	11	–	2	4	Scituate, . .	–	–	1	–	–
Northbridge, . .	–	16	15	6	3	Seekonk, . .	–	–	1	1	–
North Brookfield,	–	1	–	1	–	Sharon, . . .	–	–	1	1	17
Northfield, . .	–	1	3	1	1	Sheffield, . .	–	8	–	1	87
North Reading, .	–	1	1	–	–	Shirley, . . .	–	–	2	–	5
Norton, . . .	–	20	–	–	2	Shrewsbury, .	–	3	–	2	2
Norwell, . .	–	–	1	2	–	Shutesbury, . .	–	4	–	–	–
Norwood, . .	–	9	47	10	62	Somerset, . .	–	–	5	–	–
Oakham, . .	–	2	–	–	1	Somerville, . .	–	114	334	73	246
Orleans, . .	–	–	1	–	–	Southampton, .	–	5	3	3	–
Otis, . . .	–	–	–	1	–	Southborough, .	–	2	–	–	–
Palmer, . . .	–	5	9	14	5	Southbridge, .	–	–	148	2	–
Paxton, . . .	–	–	1	–	–	South Hadley, .	–	19	3	5	5
Peabody, . .	–	9	16	5	4	Spencer, . .	–	1	21	1	–
Pelham, . . .	–	–	–	–	1	Springfield, . .	–	112	247	77	44
Pembroke, . .	–	–	–	–	8	Stockbridge, . .	–	4	–	1	–
Pepperell, . .	–	8	–	–	47	Stoneham, . .	–	3	7	–	2
Pittsfield, . .	5	33	56	11	2	Stoughton, . .	–	15	9	4	13
Plymouth, . .	–	17	2	40	62	Stow, ...	–	3	–	–	1
Princeton, . .	–	2	–	1	–	Sturbridge, . .	–	–	1	–	–
Provincetown, .	–	–	9	–	–	Sudbury, . .	–	–	–	–	1
Quincy, . . .	–	35	73	5	108	Sutton, . . .	–	–	1	1	1
Raynham, . .	–	3	–	–	–	Swampscott, .	–	6	6	1	2
Reading, . .	–	7	4	8	4	Swansea, . .	–	–	3	–	–
Rehoboth, . .	–	6	–	–	–	Taunton, . .	–	41	27	1	–
Revere, . . .	–	14	42	3	–	Templeton, . .	–	5	13	1	–
Rockland, . .	–	9	5	7	10	Tewksbury, . .	–	–	9	3	3
Rockport, . .	–	4	28	–	–	Tisbury, . .	–	–	–	2	1
Rowley, . .	–	2	3	2	1	Topsfield, . .	–	–	3	–	–
Russell, . . .	–	1	–	–	–	Townsend, . .	–	–	3	1	7
Salem, . . .	–	26	88	23	31	Truro, . . .	–	–	–	1	–

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Fifty-nine Cities and Towns during 1904 — Concluded.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Tyringham,	–	–	–	–	4	Westminster,	–	2	1	2	–
Upton,	–	1	–	2	1	West Newbury,	–	1	2	–	–
Uxbridge,	–	30	–	1	1	Weston,	–	2	–	1	2
Wakefield,	–	9	6	11	65	Westport,	–	2	2	1	12
Walpole,	–	7	1	–	–	West Springfield,	–	7	55	1	–
Waltham,	–	54	48	33	32	Westwood,	–	2	–	–	–
Ware,	–	20	3	–	–	Weymouth,	–	11	14	5	46
Wareham,	–	–	6	–	–	Whitman,	–	12	4	–	41
Warren,	–	32	4	–	1	Wilbraham,	–	2	4	–	5
Watertown,	–	19	13	4	32	Williamsburg,	–	–	1	–	–
Wayland,	–	1	–	–	–	Williamstown,	–	9	5	2	–
Webster,	–	15	7	–	–	Wilmington,	–	3	–	3	–
Wellesley,	–	19	3	1	3	Winchendon,	–	4	4	5	7
Westborough,	–	3	1	5	1	Winchester,	–	6	15	4	83
West Boylston,	–	–	–	1	–	Winthrop,	–	8	5	14	9
West Brookfield,	–	3	–	–	–	Woburn,	–	19	16	6	1
Westfield,	–	8	33	11	5	Worcester,	–	150	108	103	64
Westford,	–	–	1	5	2	Yarmouth,	–	–	–	–	53
Westhampton,	–	–	1	–	3	Total,	100	4,100	6,772	2,605	12,511

Anthrax occurred in the following place: —

Lynn,	1

Glanders occurred in the following places: —

Chelsea,	1
Fall River,	1
Total,	2

Leprosy occurred in the following places: —

Boston,	2
Harwich,	1
Total,	3

List of Cities and Towns from which no Reports were received.

I. Cities.

None.

II. Towns having a Population of More than 5,000.

Orange. — 1.

III. Towns having a Population of More than 1,000 but Less than 5,000 in Each.

Belchertown,
Dennis,
Hamilton,
Hinsdale,
Hull,
Nantucket,
Oxford,
Rutland,
Sterling. — 9.

IV. Towns having Less than 1,000 Inhabitants.

Alford,
Ashby,
Berkley,
Blandford,
Bolton,
Boxford,
Brimfield,
Burlington,
Chesterfield,
Chilmark,
Clarksburg,
Cummington,
Dover,
Eastham,
Egremont,
Erving,
Florida,
Gay Head,
Goshen,
Gosnold,
Granby,
Greenwich,
Halifax,
Hampden,
Hancock,
Hawley,
Heath,
Holland,
Lanesborough,
Leverett,
Lynnfield,
Marion,
Middlefield,
Monterey,
Montgomery,
Mt. Washington,
New Ashford,
New Braintree,
New Salem,
Norfolk,
Peru,
Petersham,
Phillipston,
Plainfield,
Plympton,
Prescott,
Richmond,
Rochester,
Rowe,
Royalston,
Savoy,
Sunderland,
Tolland,
Tyngsborough,
Wales,
Warwick,
Washington,
Wellfleet,
Wendell,
Wenham,
West Tisbury,
Whately,
Windsor,
Worthington. — 64.

The following towns sent notice to the Board that no infectious diseases had been reported within their limits during the year 1904: —

Bourne,
Buckland,
Carver,
Charlemont,
Conway,
Cottage City,
Edgartown,
Enfield,
Hanson,
Kingston,
Lenox,
Lunenburg,
New Marlborough,
Randolph,
Shelburne,
Sherborn,
Southwick,
West Bridgewater,
West Stockbridge,
Wrentham. — 20.

A supply of postal cards for the purpose of reporting infectious diseases to the State Board of Health, as required by statute, will be forwarded to any local board of health on application to the secretary of the State Board, Room 141, State House, Boston.

IV.

OFFICIAL RETURNS OF DEATHS IN CITIES AND LARGE TOWNS (REVISED LAWS, CHAPTER 75, SECTION 12).

In the following summary, the statistics of deaths required by chapter 75, section 12, of the Revised Laws, are presented. These statistics are returned to the Board from each city and town which has, "according to the latest census, more than five thousand inhabitants."

The cities and towns which have contributed these returns for the year 1904 comprise nearly the same list as that of 1903. This list embraces all of the 33 cities and the towns having more than 5,000 inhabitants in each.

As the estimated population of Easton for 1904 is over 5,000, a return was sent in by that town, this being the first time it has appeared in the list. Reading has also voluntarily contributed returns of deaths to the Board during the past seven years, although not required by law to do so.

The return from the town of Montague is made for the first time, although the local authorities have repeatedly been requested to submit returns in accordance with the requirements of the statute. This year the Board made repeated requests, which were ignored ; and a communication was forwarded, stating that, unless immediate attention was paid to the requests, application would be made for a writ of mandamus. Finally, the matter was placed in the hands of the Attorney-General, and preparations were made to summon the delinquents; but proceedings were stopped by the receipt of the desired statistics.

The list for the year 1904 includes 95 cities and towns. In order to allow for the growth of population, and hence to arrive at a fairly accurate estimate of the death-rates of these cities and towns, an estimate of the population of each city and town in 1904 has been made, this estimate being based upon the rate of growth between the two census years 1895 and 1900.

The total estimated population of this group of cities and towns in 1904 was 2,638,585, or about 85 per cent. of the estimated total population of the State in that year.

The whole number of registered deaths in these towns in 1904 was 40,806, and the death-rate, as calculated from the foregoing estimated population, was 15.47 per 1,000 of the living population, that of the previous year having been 16.14 per 1,000, and that of 1902 16.21 per 1,000.

These were not only the lowest death-rates of this reporting population observed during the ten years since the enactment of the law requiring these returns, but they were also considerably lower than the mean annual death-rate of the State for the fifty years ended Dec. 31, 1900, which was 19.22 per 1,000.

Sexes. — The number of deaths of males was 20,593, or 50.47 per cent. of the whole number of deaths whose sex was known; and the deaths of females were 20,207, or 49.53 per cent. There were 6 in which the sex was not stated in the returns.

Ages. — The deaths by four groups of ages were as follows: —

AGES.	Deaths. **1904.**	PERCENTAGES OF ALL DEATHS.		AGES.	Deaths. **1904.**	PERCENTAGES OF ALL DEATHS.	
		1904.	**1903.**			**1904.**	**1903.**
Under 1 year, .	8,707	21.35	21.38	20 to 50 years, .	10,200	25.01	24.36
1 to 20 years, .	5,534	13.57	15.39	50 and over, .	16,350	40.08	38.86

Infant Mortality. — The deaths of infants under one year old were 8,707, or 21.34 per cent. of the total mortality, as compared with 21.38 per cent. in 1903; and this was the lowest rate of infant mortality during the period of eleven years since the law was enacted requiring these returns; that of the five years 1900–1904 respectively constituted 23, 21.6, 21.7, 21.38 and 21.34 per cent. of the total mortality.

The deaths of children under five years old were 11,841, or 29 per cent. of the total mortality, as compared with 29.7 per cent. for the same age in 1903.

All of the percentages in the foregoing table were estimated upon the number of deaths of those whose ages were stated in the returns. The total number of deaths in which the age was not specified was 15; in 1903 it was 44.

Still-births. — The number of still-births was 2,716, and when compared with the total mortality (still-births included), this was 6.2 per cent. of the total deaths and still-births combined. In 1903 the percentage was 6.3.

Months and Quarters. — The number of deaths in each quarter of the year is shown in the following table: —

	Deaths. **1904.**	PERCENTAGES.	
		1904.	**1903.**
First quarter, ...	11,076	27.14	27.23
Second quarter, ...	9,675	23.71	23.75
Third quarter, ...	10,318	25.29	26.09
Fourth quarter, ...	9,734	23.86	22.93
Total, ...	40,803	100.00	100.00

These percentages differ but little from the mean of several years, which usually shows the highest mortality in the third quarter of the year. In 1899, 1901, 1903 and 1904 the highest mortality was in the first quarter.

During the forty-year period (1856–95) the mortality was generally above the mean in the third quarters of the years and below it in the other three quarters.

The intensity of the seasonal death-rate is more accurately shown in the following table, the method employed being explained on page 382 in Section III. of these summaries, relating to disease notification. By this method the errors which are due to differences in the length of the months are eliminated.

	Deaths in Each Month.	Mean Daily Deaths per Month. 1904.*	CENTESIMAL RATIO.	
			1904.*	**1903.**
January, . .	3,751	121.0	108.5	108.4
February, . .	3,453	119.1	106.8	113.9
March, . .	3,872	124.9	112.0	109.3
April, . .	3,629	121.0	108.5	105.7
May, . . .	3,311	106.8	95.8	96.3
June, . . .	2,735	91.2	81.8	83.7
July, . . .	3,353	108.2	97.0	107.3
August, . .	3,601	116.2	104.2	105.1
September, .	3,364	112.1	100.5	98.0
October, . .	3,091	99.7	89.4	88.3
November, .	3,200	106.7	95.7	86.8
December, . .	3,443	111.1	99.6	97.6
Annual mean,	–	111.5	100.0	100.0

* In ascertaining the mean daily deaths and the centesimal ratios, allowance was made for the fact that 1904 had 366 days.

The figures in the foregoing table indicate a departure in excess of the mean death-rate in the first four months of the year and in August and September, while that of the remaining months was below the mean.

The mean maximum departure from the death-rate for each month for the period of twenty years, 1856–75, was 32.9 per cent. in August, and the twenty-year period 1876–95 it was 20 per cent. in August, while that of March, 1904, was 12 per cent. and those of January and April, 1904, were both 8.5 per cent.

In the two years having the highest death-rates in Massachusetts in the past half-century or more (1849 and 1872) the maximum departures from the yearly means were, respectively, 83.4 per cent. in August, 1849, and 40 per cent. in August, 1872. That of January, 1890, the month in which the epidemic of influenza was at its maximum, was 43.4 per cent. above the mean.

The figures for 1904, when compared with those of earlier years in the past half-century, show a much greater uniformity in the seasonal mortality, since serious epidemics have not prevailed in the State either in the past year or in any of the years of the past decade. The death-rate of 1904, like those of 1903, 1902 and 1901, was remarkably low.

Death-rates of Cities and Large Towns. — In Table II., last column, the death-rates of cities and towns having over 5,000 inhabitants are given. These death-rates are obtained by comparing the deaths in each city and town with the estimated population. They vary from a minimum of 8.5 in Bridgewater to 21.5 per 1,000 in Blackstone.

The following cities and towns had death-rates above 19 per 1,000 in 1904: Blackstone, 21.5; Stoneham, 20.0; New Bedford, 19.6; and Newburyport, 19.3.

Of the foregoing, Blackstone and New Bedford also had death-rates above 19 per 1,000 in 1903.

The following cities and towns had death-rates less than 12 per 1,000 in 1904: Williamstown, 11.7; Fitchburg, 11.6; Everett, 11.5+; Norwood, 11.4; North Attleborough, 11.4; Leominster, 11.3; Revere, 11.2; Clinton, 11.1; Whitman, 10.9+; Medford, 10.5; Newton, 10.4; Brookline, 10.2; Danvers, 10.2; Concord, 8.9+; Wellesley, 8.9; Winthrop, 8.7; Bridgewater, 8.5; of these, Bridgewater, Everett, Newton, Revere, Wellesley, Whitman, Williamstown and Winthrop also had death-rates below 12 per 1,000 in 1903.

The following table presents the mean death-rates of cities of over 25,000 population for the five census years 1870, 1875, 1880, 1885 and 1890, together with the death-rates for the years 1900 and 1904.

In all of these cities except two (Gloucester and Malden) there appears to have been decided improvement.

Death-rates of Certain Cities having a Population of More than 25,000. Mean Death-rates of the Five Census Years 1870, 1875, 1880, 1885, 1890, and for 1900 and 1904.

	Mean Death-rates, 1870, 1875, 1880, 1885 and 1890.	Death-rate, 1900.	Death-rate. 1904.		Mean Death-rates, 1870, 1875, 1880, 1885 and 1890.	Death-rate, 1900.	Death-rate, 1904.
Boston, . .	24.1	20.8	17.4*	Haverhill, .	17.8	15.2	13.8
Worcester, .	19.7	18.8	14.6*	Salem, . .	22.1	19.6	18.8
Fall River, .	23.4	21.0	17.2	Chelsea, . .	19.7	19.1	17.2*
Lowell, . .	22.5	19.5	16.6	Malden, . .	17.0	14.6	16.6
Cambridge, .	19.9	16.8	14.3	Newton, . .	13.1	14.9	10.4
Lynn, . .	17.8	15.8	14.9	Fitchburg, .	17.0	14.9	11.6
Lawrence, .	26.5	20.0	15.8	Taunton, .	19.5	21.1	18.1*
New Bedford, .	20.9	20.6	19.6	Gloucester, .	21.8	14.6	16.2
Springfield, .	19.3	18.4	16.0	North Adams,	17.7†	14.2	12.8
Somerville, .	18.2	15.7	13.7	Quincy, . .	18.7	14.4	13.0
Holyoke, . .	23.1	21.5	16.3	Waltham, .	15.3	15.6	12.8
Brockton, .	16.2	13.8	12.2				

* NOTE. — These figures for Boston, Chelsea, Worcester and Taunton include all deaths. By exclusion of deaths of non-residents in Boston and deaths in public and private institutions in the other three cities, the death-rates would be reduced to 16.4 in Chelsea, 15.9 in Boston, 14.4 in Taunton and 13.3 in Worcester.

† North Adams, for 1880, 1885 and 1890 only.

CAUSES OF DEATH.

In Table III. the mortality of the cities and towns embraced in this summary is presented in absolute figures, classified according to the principal causes of death. The same figures are again presented in relative terms in Table IV., for the whole group of cities and towns combined. Two sets of figures are given in Table IV., in one of which the mortality from each principal cause of death is compared with the estimated population of the group for 1904, as well as for each of the last five years, and in the other with the total mortality of the group of cities and towns.

By this it appears that the general death-rate from all causes, as shown in the lower line at the left of the table, 154.65 per 10,000 living, or, as usually stated, 15.47 per 1,000, was lower than that of any of the preceding years; and, since the population comprised in these returns constitutes over 85 per cent. of that of the whole State, there are indications that the death-rate of the State was less than that of any year in the past century.

As in 1903, the decline in the general death-rate is chiefly due to a decrease in the relative number of deaths from infectious diseases, and especially from those which are usually considered preventable.

The death-rates from each of the following causes was less than that of 1903: smallpox, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, cerebro-spinal meningitis, puerperal fever, influenza, malarial fever, cholera infantum, pneumonia, bronchitis and diseases of the kidneys. Those of measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, cerebro-spinal meningitis, puerperal fever, malarial fever, cholera infantum, pneumonia and bronchitis were also less than the death-rates from the same causes in any of the last five years.

The following table, first published in the report of 1899, presents the combined death-rate from eight of the principal infectious diseases, and also shows that this combined death-rate in 1904 was less than that of any of the years embraced in this series of reports.

The diseases referred to are consumption, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, puerperal fever and cholera infantum.

The combined death-rate per 10,000 of the population from these eight causes for the ten years (1895–1904) in the cities and towns included in this report (about five-sixths of the total population of the State) was as follows: —

Combined Death-rate from Eight Principal Infectious Diseases.

YEAR.	Combined Death-rate per 10,000.	YEAR.	Combined Death-rate per 10,000.
1895,	46.4	1900,	40.7
1896,	46.8	1901,	33.5
1897,	39.7	1902,	30.9
1898,	36.3	1903,	30.7
1899,	35.2	1904,	27.0

The death-rate from consumption, while less than in 1902, was higher than during 1903, being 16.05 in 1904, 15.66 in 1903 and 16.38 in 1902.

The seasonal table which appeared in the earlier reports, presenting the deaths by months for each city and town and for the whole State, is omitted in the present report, since the details presented in this table are not of essential value. Its chief value consisted in the column of total figures for the State, which is retained essentially in the table on page 390.

The table of percentages of total mortality shown in Table IV. acts in a measure as a check or control in case of erroneous estimates of population.

The changes in the death-rate from consumption, typhoid fever and puerperal fever (see child-birth in report of 1896, page 804) were quite fully treated in the report of 1896. To these may be added the later comments on the changes in the death-rate from diphtheria, which appear in the figures of the past ten years.

The following preventable causes of death, consumption, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, puerperal fever and cholera infantum, together constituted 27.2 per cent. of the total mortality in 1894, but had fallen off to 24.2, 24.2, 21.9, 21.1, 20.4, 22.3, 19.9, 19.0, 19.0 and 17.5 in the ten succeeding years; while the principal acute lung diseases, diseases of the heart, brain, kidneys, cancer, suicide and accident had increased from 35.7 per cent. of the total mortality to 36.9, 36.9, 38.5, 39.2, 40.2, 38.6, 40.1, 42.7, 43.0 and 45.7 per cent. in the same year.

These all combined constituted the greater part of the total mortality in each of the eleven years 1894–1904, and of the diseases specified in the table entitled the "Balance of Mortality," in the annual report of 1896, page 812.

TABLE I.

Population of Cities and Large Towns estimated for 1904.

REPORTING CITIES AND TOWNS.	Estimated Population for **1904.**	REPORTING CITIES AND TOWNS.	Estimated Population for **1904.**
Adams,	14,745	Arlington,	10,275
Amesbury,	9,473	Athol,	7,061
Amherst,	5,224	Attleborough,	14,561
Andover,	7,349	BEVERLY,	15,807

Table I. — Concluded.

Reporting Cities and Towns.	Estimated Population for **1904.**	Reporting Cities and Towns.	Estimated Population for **1904.**
Blackstone,	5,721	NEWBURYPORT,	14,419
BOSTON,	617,950	NEWTON,	39,310
Braintree,	6,517	NORTH ADAMS,	29,201
Bridgewater,	6,702	NORTHAMPTON,	20,314
BROCKTON,	46,601	North Attleborough,	7,793
Brookline,	23,576	Northbridge,	8,436
CAMBRIDGE,	100,998	Norwood,	6,204
CHELSEA,	36,499	Orange,	5,948
CHICOPEE,	21,692	Palmer,	8,557
Clinton,	15,694	Peabody,	12,406
Concord,	6,032	PITTSFIELD,	22,870
Danvers,	8,830	Plymouth,	11,139
Dedham,	7,653	QUINCY,	26,798
Easthampton,	6,255	Reading,	5,169
Easton,	5,168	Revere,	13,609
EVERETT,	30,209	Rockland,	5,327
FALL RIVER,	119,349	SALEM,	37,188
FITCHBURG,	36,335	Saugus,	5,552
Framingham,	12,974	SOMERVILLE,	70,413
Franklin,	5,017	Southbridge,	11,716
Gardner,	12,324	Spencer,	7,639
GLOUCESTER,	26,121	SPRINGFIELD,	72,020
Great Barrington,	6,702	Stoneham,	6,197
Greenfield,	9,283	Stoughton,	5,578
HAVERHILL,	39,061	TAUNTON,	34,577
Hingham,	5,251	Wakefield,	10,078
HOLYOKE,	50,538	WALTHAM,	25,797
Hudson,	5,570	Ware,	8,751
Hyde Park,	14,500	Watertown,	11,575
LAWRENCE,	72,348	Webster,	9,608
Leominster,	15,711	Wellesley,	5,748
LOWELL,	104,402	Westborough,	5,532
LYNN,	73,875	Westfield,	13,809
MALDEN,	37,205	West Springfield,	7,889
Marblehead,	7,582	Weymouth,	11,350
MARLBOROUGH,	13,609	Whitman,	6,483
MEDFORD,	21,956	Williamstown,	5,113
MELROSE,	13,819	Winchendon,	5,409
Methuen,	8,968	Winchester,	8,128
Middleborough,	7,041	Winthrop,	7,550
Milford,	13,771	WOBURN,	14,315
Milton,	7,426	WORCESTER,	136,925
Montague,	6,224		
Natick,	10,028	Total,	2,638,585
NEW BEDFORD,	68,863		

The death-rate of Amesbury, Athol, Blackstone, Franklin, Gloucester, Marblehead, Marlborough, Newburyport, Rockland and Stoneham was based on the population of 1900, these towns having slightly decreased in population in the five years which elapsed between the census of 1895 and 1900.

TABLE II.

Total Deaths, Deaths by Sexes and Age Periods and Still-births in Cities and Towns having over 5,000 Inhabitants in Each with General Death-rates estimated for 1904.

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
Adams, ...	199	92	107	–	17	72	14	5	1	–	8	1	5	11	14	15	18	15	9	11	–	13.50
Amesbury, ...	160	75	85	–	9	33	2	–	–	1	2	1	5	6	11	20	16	19	21	23	–	16.89
Amherst, ...	81	41	40	–	–	15	–	–	–	–	–	1	2	1	5	4	7	9	20	17	–	15.51
Andover, ...	100	49	51	–	1	10	7	1	–	–	2	2	2	5	9	8	12	18	17	7	–	13.61
Arlington, ...	134	63	70	1	12	20	1	–	1	1	3	–	5	5	19	10	18	20	20	11	–	13.04
Athol, ...	111	62	49	–	10	16	2	2	2	1	–	1	2	4	10	6	11	10	27	17	–	15.72
Attleborough, ...	178	82	96	–	7	44	6	4	2	1	2	1	7	8	6	22	21	14	24	16	–	12.22
BEVERLY, ...	226	112	114	–	15	24	2	3	1	3	2	5	3	14	14	17	32	36	44	26	–	14.30
Blackstone, ...	123	64	59	–	11	22	5	2	1	–	6	1	1	8	14	13	12	17	14	7	–	21.50
BOSTON,*	10,757	5,568	5,189	–	663	2,207	455	217	126	100	244	141	222	901	1,197	1,119	1,217	1,182	916	513	–	15.85†
Braintree, ...	104	59	45	–	12	22	4	2	3	1	2	–	3	7	3	8	11	13	18	7	–	15.96
Bridgewater,‡	57	23	34	–	3	10	1	–	–	–	–	–	2	5	–	4	7	9	12	7	–	8.50
BROCKTON, ...	567	282	285	–	48	100	25	10	10	3	7	5	12	45	48	47	65	75	74	41	–	12.17
Brookline, ...	241	109	132	–	14	21	5	3	–	–	1	3	4	17	21	22	26	47	40	31	–	10.22
CAMBRIDGE, ...	1,444	709	735	–	91	296	58	22	15	17	22	18	44	115	146	119	139	187	143	103	–	14.30
CHELSEA,§	678	389	289	–	37	123	26	11	10	6	18	4	17	51	54	34	78	120	83	43	–	16.36†
CHICOPEE, ...	338	178	160	–	31	111	17	1	7	5	12	6	7	26	23	19	36	32	26	10	–	15.58
Clinton, ...	174	91	83	–	15	35	10	–	2	1	2	2	5	16	17	19	19	25	15	6	–	11.09
Concord, ...	54	26	28	–	3	10	1	1	–	1	3	–	3	9	5	2	3	5	8	3	–	8.95
Danvers,‖	90	36	54	–	4	9	1	1	–	–	3	–	4	4	6	7	9	10	17	19	–	10.19
Dedham, ...	128	70	58	–	10	19	1	–	–	1	2	1	2	12	6	7	15	18	23	21	–	16.73
Easthampton, ...	79	39	40	–	9	13	2	–	1	–	4	–	3	7	2	9	13	8	15	2	–	12.63
Easton, ...	76	45	31	–	3	9	1	1	1	–	2	3	–	5	2	5	12	15	15	5	–	14.71

EVERETT,	349	162	187	–	29	79	11	7	2	4	2	12	8	25	28	27	46	40	43	15	–	11.55
FALL RIVER,	2,047	986	1,061	–	150	812	72	71	69	86	61	52	36	144	137	120	145	125	72	45	–	17.15
FITCHBURG,	422	197	225	–	32	107	10	7	2	1	6	10	15	36	32	29	44	41	46	36	–	11.61
Framingham,	172	88	84	–	11	22	4	–	2	2	4	4	7	15	16	17	24	20	15	20	–	13.26
Franklin,	76	32	44	–	4	10	–	1	–	–	–	3	1	5	6	10	9	9	12	10	–	15.15
Gardner,	180	105	75	–	19	60	8	4	1	1	3	5	3	12	12	10	13	16	13	19	–	14.61
GLOUCESTER,	424	218	206	–	48	67	16	10	9	1	12	10	12	36	33	38	31	56	55	38	–	16.23
Great Barrington,	82	42	40	–	3	11	5	–	1	–	1	–	4	4	3	8	9	11	16	9	–	12.24
Greenfield,	144	69	75	–	6	20	8	–	3	1	6	1	3	12	12	9	11	12	24	21	1	15.51
HAVERHILL,	540	267	273	–	53	89	20	5	6	4	9	17	9	40	46	51	58	75	74	37	–	13.82
Hingham,	71	32	39	–	3	4	1	–	–	–	–	1	2	1	4	4	8	12	21	13	–	13.52
HOLYOKE,	826	398	428	–	66	273	31	12	7	9	21	12	18	68	61	74	81	78	67	14	–	16.34
Hudson,	76	40	36	–	11	11	–	–	–	–	5	1	2	5	7	10	8	8	12	7	–	13.64
Hyde Park,	208	100	103	5	18	46	9	6	2	1	7	3	1	13	14	18	30	29	21	7	1	14.35
LAWRENCE,	1,141	575	566	–	116	308	63	17	15	13	17	15	30	88	83	97	115	132	94	52	2	15.77
Leominster,	178	70	108	–	8	27	9	3	–	–	2	2	5	11	20	11	17	24	21	26	–	11.33
LOWELL,	1,736	860	876	–	43	498	92	41	24	18	34	25	40	124	134	127	170	192	143	74	–	16.63
LYNN,	1,104	547	557	–	95	213	23	16	8	13	23	15	32	92	103	99	100	152	144	70	1	14.94
MALDEN,	488	235	253	–	33	90	20	9	6	3	10	7	15	34	37	40	46	60	71	40	–	13.12
Marblehead,	139	72	67	–	3	10	3	5	1	2	4	1	4	7	7	7	17	22	27	22	–	18.33
MARLBOROUGH,	180	88	92	–	9	27	8	3	2	1	5	4	4	8	15	13	19	26	26	18	1	13.23
MEDFORD,	230	103	127	–	23	42	6	4	2	2	3	4	10	8	11	21	29	32	34	22	–	10.48
MELROSE,	199	99	100	–	13	29	8	1	3	–	3	2	6	13	17	12	24	24	31	26	–	14.40
Methuen,	121	71	50	–	15	25	2	1	2	1	5	–	4	6	18	14	5	16	15	7	–	13.49
Middleborough,	132	71	61	–	2	18	3	2	–	–	1	–	1	4	8	11	19	17	27	21	–	18.75
Milford,	172	87	85	–	18	17	8	3	2	2	4	1	2	13	25	22	14	26	18	15	–	12.49
Milton,	102	47	55	–	8	6	5	3	3	–	1	5	6	6	7	8	13	7	13	19	–	13.74
Montague,	118	65	53	–	10	16	2	5	–	–	1	2	4	10	12	13	9	21	13	7	3	18.96
Natick,	125	70	55	–	7	8	1	1	–	–	3	1	2	9	11	14	18	31	14	12	–	12.47
NEW BEDFORD,	1,347	711	636	–	124	423	60	28	11	13	16	11	33	115	93	97	118	135	114	80	–	19.56
NEWBURYPORT,	278	119	159	–	19	26	10	4	4	1	4	3	4	26	16	18	20	56	41	45	–	19.28

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* Non-residents, 963 included. † In obtaining this death-rate, deaths occurring in public institutions were not included, many being non-residents.

‡ State Farm, deaths at, not included. § Soldiers' Home, 81 included. || Insane Asylum, 194 not included.

TABLE II. — *Concluded.*

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
NEWTON, ...	410	194	216	–	18	54	15	5	6	4	8	7	17	24	40	26	35	60	67	42	–	10.43
NORTH ADAMS, . . .	374	198	176	–	29	88	15	7	4	4	22	3	9	37	26	31	34	39	30	27	–	12.81
NORTHAMPTON,* . .	345	180	165	–	10	70	14	4	1	–	5	3	9	25	20	17	41	54	53	29	–	13.88†
North Attleborough, . .	89	42	47	–	9	13	2	1	–	–	4	–	3	5	7	6	9	18	13	8	–	11.41
Northbridge, ...	119	59	60	–	8	32	5	1	–	3	–	1	4	18	7	5	9	9	15	10	–	14.11
Norwood, ...	71	39	32	–	9	15	4	2	2	–	2	2	1	2	6	4	5	12	9	5	–	11.44
Orange, ...	80	45	35	–	6	7	3	–	1	–	2	1	2	4	9	3	8	5	14	21	–	14.16
Palmer, ...	134	70	64	–	9	47	8	8	–	3	2	–	3	10	4	10	5	16	12	6	–	15.66
Peabody, ...	172	88	84	–	14	35	3	–	–	3	3	1	6	10	15	12	23	21	20	20	–	13.86
PITTSFIELD, ...	405	199	206	–	17	54	10	7	2	4	14	1	14	41	36	34	32	50	65	40	1	17.71
Plymouth, ...	195	109	86	–	5	28	9	2	2	1	3	2	5	15	11	15	21	19	41	20	1	17.51
QUINCY, ...	347	166	181	–	23	75	19	6	5	4	14	4	13	30	23	28	28	35	40	23	–	12.95
Reading, ...	75	42	33	–	6	6	2	–	2	2	1	1	–	6	5	5	1	11	16	17	–	14.51
Revere, ...	153	73	80	–	16	35	6	1	4	2	3	1	2	14	9	16	14	22	17	7	–	11.24
Rockland, ...	80	37	43	–	3	7	2	–	1	2	1	–	–	5	9	7	10	11	15	10	–	15.02
SALEM, ...	698	337	361	–	44	166	20	6	7	5	10	11	17	52	52	62	69	86	79	54	–	18.77
Saugus, ...	92	47	45	–	6	16	4	1	2	1	1	–	3	6	5	6	9	11	19	8	–	16.57
SOMERVILLE, ...	964	492	472	–	63	169	33	12	15	9	22	17	20	60	69	89	97	133	144	75	–	13.69
Southbridge, ...	196	106	90	–	7	58	13	11	11	3	11	3	6	10	12	13	5	13	15	11	1	16.73
Spencer, ...	97	51	46	–	6	15	–	1	1	–	2	1	2	7	11	8	11	15	12	11	–	12.70
SPRINGFIELD, ...	1,149	549	600	–	72	207	28	12	14	8	27	22	28	97	105	93	115	156	146	91	–	15.95
Stoneham, ...	124	61	63	–	6	12	1	3	1	1	–	–	–	9	11	13	15	16	24	18	–	20.01
Stoughton, ...	106	54	52	–	4	15	3	2	–	1	2	2	2	10	10	13	9	9	14	14	–	19.00
TAUNTON,‡	624	316	308	–	38	122	18	10	10	4	11	4	10	42	50	52	61	89	93	47	1	14.40†
Wakefield, ...	133	67	66	–	11	20	3	1	–	–	3	–	2	8	10	10	15	16	29	16	–	13.20

WALTHAM, ...	330	153	177	–	14	43	4	3	2	4	11	6	10	32	29	27	30	46	54	29	–	12.79
Ware, ...	126	62	64	–	7	35	3	–	2	–	2	–	1	14	13	6	10	8	15	17	–	14.40
Watertown, ...	154	77	77	–	23	25	5	3	1	3	2	1	1	8	19	12	18	17	20	18	1	13.30
Webster, ...	160	95	65	–	12	43	10	2	–	–	1	1	4	14	13	8	14	19	20	11	–	16.65
Wellesley, ...	51	24	27	–	3	6	2	–	1	–	1	–	2	6	7	1	7	3	7	7	1	8.87
Westborough,§ . . .	183	89	94	–	2	6	1	–	1	–	1	1	1	11	17	21	37	36	38	12	–	12.65†
Westfield, ...	204	110	94	–	17	40	–	3	2	2	3	2	5	16	11	16	29	19	30	26	–	14.77
West Springfield, . .	112	61	51	–	4	26	3	–	2	1	3	4	2	13	4	8	7	20	14	5	–	14.20
Weymouth, ...	176	80	96	–	12	16	4	5	–	3	4	2	5	10	16	12	16	22	39	22	–	15.51
Whitman, ...	71	39	32	–	2	11	1	–	–	2	2	–	1	6	2	5	11	11	12	7	–	10.95
Williamstown, . . .	60	23	37	–	3	12	1	1	–	1	1	–	2	1	3	2	12	6	9	9	–	11.73
Winchendon, . . .	81	38	43	–	6	11	6	–	2	–	2	1	3	4	6	6	11	12	10	7	–	14.98
Winchester, ...	106	47	59	–	9	17	3	–	–	–	4	–	4	4	9	9	12	13	13	18	–	13.04
Winthrop, ...	66	31	35	–	7	10	–	1	–	–	4	–	1	7	4	9	4	13	11	2	–	8.74
WOBURN, ...	195	102	93	–	9	41	10	4	4	1	–	2	5	9	11	12	21	35	24	16	–	13.62
WORCESTER,‖ . . .	1,993	1,051	942	–	123	364	66	25	15	11	53	27	46	161	179	183	220	255	238	150	–	13.26†
Totals, ...	40,806	20,593	20,207	6	2,716	8,707	1,523	705	493	413	887	559	954	3,135	3,565	3,500	4,207	4,870	4,494	2,779	15	15.47

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* Insane Hospital, 63 included.

† In obtaining this death-rate, deaths occurring in public institutions were not included, many being non-residents.

‡ Insane Asylum, 126 included.

§ Insane Asylum, 113 included.

‖ Insane Asylum and Insane Hospital, 178 included.

TABLE III.

Deaths from Specified Causes in Cities and Towns having More than 5,000 Inhabitants in Each.

	Consumption.	Smallpox.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
Adams, . . .	14	1	–	–	5	2	3	2	–	1	2	–	17	–	–	20	2	5	4	6	4	3	–	–	107
Amesbury, . . .	16	–	–	–	–	2	4	–	1	–	1	–	6	2	2	25	1	33	15	11	12	–	3	–	26
Amherst, . . .	5	–	–	–	–	–	–	1	–	–	–	–	5	1	1	4	2	6	3	5	7	–	1	–	40
Andover, . . .	7	–	–	–	2	–	1	3	–	–	–	–	–	–	–	15	–	20	7	1	12	–	6	–	25
Arlington, . . .	6	–	–	1	2	–	–	5	1	–	–	–	4	1	–	8	3	15	–	1	5	2	4	–	76
Athol, . . .	7	–	–	–	2	–	–	3	1	–	–	–	4	–	–	7	1	15	25	11	2	1	2	2	28
Attleborough, . .	20	–	–	–	3	–	1	–	–	–	2	–	11	1	–	7	5	16	20	13	10	–	14	–	55
BEVERLY, . . .	26	–	–	–	1	1	3	4	1	–	–	1	4	–	1	23	4	40	29	15	13	1	6	–	52
Blackstone, . .	6	–	–	–	1	–	1	2	–	–	–	–	3	4	1	21	6	9	3	4	–	2	8	–	52
BOSTON, . . .	1,269	–	89	39	206	29	135	37	62	18	65	2	206	20	422	1,323	273	1,056	648	543	565	80	451	90	3,103
Braintree, . . .	9	–	1	3	1	1	2	1	1	–	1	3	5	–	1	8	4	11	16	5	4	–	5	–	21
Bridgewater, . .	4	–	–	–	–	–	1	1	1	–	–	–	2	–	1	5	4	9	5	4	2	–	–	11	7
BROCKTON, . .	74	–	12	1	3	–	8	17	–	6	6	1	13	6	4	39	14	69	46	25	30	5	10	2	176
Brookline, . . .	13	–	–	1	1	–	1	3	3	–	2	–	3	–	1	25	7	47	18	13	23	2	2	–	74
CAMBRIDGE, . .	190	–	8	3	25	3	23	6	5	–	9	–	28	3	81	146	35	193	152	66	82	8	52	68	257
CHELSEA, . . .	59	–	3	2	13	–	11	6	–	–	10	–	18	–	7	46	13	78	50	37	27	6	10	–	281
CHICOPEE, . . .	30	–	1	3	7	1	2	1	2	–	3	–	25	–	–	21	16	27	59	20	13	1	7	2	97
Clinton, . . .	6	–	–	–	–	–	3	–	1	–	–	–	4	2	7	26	7	20	–	8	3	3	7	–	77
Concord, . . .	8	–	–	–	–	–	–	2	1	–	2	–	–	–	–	4	1	3	8	2	4	1	2	–	16
Danvers, . . .	10	–	–	–	–	–	1	4	–	–	–	–	–	–	–	14	1	11	2	3	8	1	–	–	35
Dedham, . . .	12	–	1	–	–	–	–	1	1	–	–	3	2	1	–	9	3	22	26	7	3	–	3	1	33
Easthampton, . .	12	–	–	–	1	–	–	4	–	2	–	2	4	2	1	4	–	4	7	4	1	1	4	–	26
Easton, . . .	8	–	–	–	–	–	–	–	–	–	1	1	1	–	–	9	1	9	2	12	4	1	2	1	24

EVERETT, . . .	45	–	–	1	7	–	2	2	–	–	4	–	8	2	1	42	7	43	1	3	13	3	8	–	157
FALL RIVER, . .	158	–	6	2	45	20	19	3	5	2	2	1	218	13	31	133	156	97	298	67	33	2	59	15	662
FITCHBURG, . .	35	1	–	–	1	3	3	–	1	–	1	1	15	1	–	41	12	52	3	8	25	3	22	15	179
Framingham, . .	15	–	–	1	–	–	2	2	–	1	1	–	–	–	–	12	1	10	8	1	5	2	13	–	98
Franklin, . . .	4	–	–	–	–	–	1	1	1	–	–	–	–	–	–	11	3	4	9	3	4	1	4	–	29
Gardner, . . .	25	–	–	–	6	2	4	10	2	–	5	–	5	–	–	13	8	12	11	8	1	1	4	–	63
GLOUCESTER, . .	7	–	–	3	6	–	2	3	–	1	–	–	6	1	–	23	4	27	1	19	13	7	12	–	289
Great Barrington, .	3	–	–	–	1	–	–	–	–	–	–	–	4	4	–	5	3	9	11	9	7	–	3	–	23
Greenfield, . . .	14	–	–	2	2	–	1	4	–	–	–	–	4	1	1	17	1	16	8	9	4	3	8	–	49
HAVERHILL, . .	64	–	7	–	2	–	5	1	1	–	4	1	–	1	17	53	9	74	63	28	33	10	25	3	138
Hingham, . . .	6	–	–	–	–	–	1	–	–	–	–	–	–	1	2	7	2	10	11	2	4	–	2	4	19
HOLYOKE, . . .	106	–	–	2	15	7	4	1	2	–	8	–	56	2	50	85	19	83	91	56	37	8	20	–	174
Hudson, . . .	12	–	–	–	–	–	2	–	–	–	1	–	3	1	–	3	1	14	7	4	6	–	3	–	19
Hyde Park, . .	29	–	–	1	–	2	–	–	1	1	–	–	7	–	3	29	4	15	8	9	6	4	10	–	79
LAWRENCE, . .	120	–	1	3	7	6	11	2	2	–	5	–	82	6	7	140	36	89	92	80	38	10	17	19	368
Leominster, . .	22	–	–	1	–	–	1	5	–	–	–	–	6	3	–	11	4	30	3	18	6	1	5	–	62
LOWELL, . . .	143	1	14	5	34	2	17	5	2	2	5	–	113	5	125	175	72	132	203	85	65	10	52	11	458
LYNN, . . .	136	–	–	–	21	1	17	6	1	–	–	–	24	1	9	104	20	117	91	73	64	10	32	9	366
MALDEN, . . .	50	–	2	1	5	–	7	1	4	–	2	–	18	3	1	66	10	74	54	19	23	1	1	1	145
Marblehead, . .	13	–	–	–	5	–	–	2	–	–	1	–	1	1	–	6	1	21	13	7	7	2	3	–	56
MARLBOROUGH, .	12	–	–	1	3	–	2	15	1	1	–	–	2	–	1	12	1	17	–	6	8	–	4	–	94
MEDFORD, . . .	16	–	–	1	2	–	2	–	–	–	–	1	12	–	–	26	4	20	2	4	18	1	1	–	120
MELROSE, . . .	20	–	–	–	2	4	1	–	–	–	2	–	1	–	–	18	10	24	20	11	17	2	11	9	47
Methuen, . . .	11	–	–	3	2	–	2	8	2	4	2	–	6	3	2	15	5	20	9	7	5	2	3	–	9
Middleborough, .	11	–	–	–	1	–	2	2	–	–	–	–	3	–	–	6	3	22	6	–	9	1	7	–	59
Milford, . . .	15	–	–	–	1	–	–	–	3	–	1	1	1	8	–	19	3	14	14	25	8	1	9	–	49
Milton, . . .	9	–	–	–	1	–	1	–	–	–	–	–	–	–	–	13	1	9	1	4	4	2	3	–	54
Montague, . . .	4	–	–	–	1	–	2	6	–	–	–	1	5	–	–	16	4	5	–	3	–	–	8	–	63
Natick, . . .	18	–	–	–	1	–	1	1	–	–	–	–	1	–	–	10	–	30	5	9	9	1	6	–	33
NEW BEDFORD, .	137	–	–	–	10	1	12	4	6	–	7	–	96	2	3	144	35	128	105	80	48	3	5	–	521
NEWBURYPORT, .	15	–	–	–	3	2	3	2	1	1	1	–	7	–	1	11	8	16	14	16	25	3	13	3	132

TABLE III. — *Concluded.*

	Consumption.	Smallpox.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
NEWTON, . . .	33	–	1	1	6	–	4	2	–	1	4	–	–	3	1	38	7	42	50	22	22	–	12	–	161
NORTH ADAMS, .	32	5	–	4	19	1	10	–	2	–	2	–	–	1	3	41	–	20	34	12	8	2	21	1	156
NORTHAMPTON, .	29	–	3	–	–	1	3	–	1	–	1	1	17	5	8	27	6	45	54	16	15	3	10	11	89
North Attleborough, .	12	–	–	–	–	–	1	–	–	–	1	2	2	–	1	9	2	6	17	6	6	2	–	–	22
Northbridge, . .	16	–	–	–	1	1	1	5	1	–	–	1	5	1	4	16	3	14	1	10	6	–	5	5	23
Norwood, . . .	2	–	–	–	3	–	–	3	–	1	–	–	3	2	–	4	4	15	7	5	–	–	–	–	22
Orange, . . .	8	–	–	–	1	–	–	6	1	–	–	–	1	–	–	4	2	9	14	8	1	2	2	1	20
Palmer, . . .	19	–	–	–	3	2	1	–	1	1	3	–	8	1	8	19	–	19	12	4	7	–	4	2	20
Peabody, . . .	13	–	–	–	2	–	1	4	–	–	–	–	7	6	2	15	7	37	14	9	10	–	4	–	41
PITTSFIELD, . .	45	–	–	–	6	–	8	12	3	6	–	–	14	5	3	46	10	72	14	24	23	–	22	47	42
Plymouth, . . .	12	–	1	–	2	–	6	6	–	1	–	–	6	–	7	11	10	29	27	13	15	–	17	–	32
QUINCY, . . .	40	–	5	1	9	1	1	–	1	–	2	–	23	–	–	39	9	55	32	11	18	4	19	–	77
Reading, . . .	12	–	–	1	1	–	–	2	–	–	–	–	1	1	–	6	1	1	7	2	5	–	3	–	32
Revere, . . .	18	–	–	–	2	1	2	5	–	–	1	1	7	1	1	15	6	23	11	8	9	–	7	–	35
Rockland, . . .	10	–	–	–	2	–	–	1	–	–	–	–	1	2	–	7	–	10	9	11	3	1	3	7	13
SALEM, . . .	56	–	–	–	11	2	8	1	–	–	3	–	46	2	9	44	25	87	28	34	43	6	16	–	277
Saugus, . . .	13	–	2	–	2	–	–	2	1	–	–	–	2	–	3	8	4	12	4	4	1	1	6	–	27
SOMERVILLE, . .	94	–	3	3	14	–	11	19	5	–	6	–	13	4	6	110	30	103	70	76	52	1	34	–	310
Southbridge, . .	19	–	–	–	18	2	–	–	–	–	–	–	4	1	7	6	4	11	1	9	4	1	3	35	71
Spencer, . . .	15	–	–	–	2	–	–	3	–	–	–	–	4	1	1	11	–	7	5	6	6	–	2	14	20
SPRINGFIELD, . .	108	–	3	12	26	4	11	3	6	7	6	–	18	2	38	79	9	141	14	114	69	7	49	24	392
Stoneham, . . .	14	–	–	–	3	–	1	–	–	1	1	–	–	–	–	13	3	20	16	10	8	–	2	–	32
Stoughton, . . .	12	–	–	–	1	–	3	–	–	–	1	–	1	–	–	10	–	11	8	7	6	–	3	–	43
TAUNTON, . . .	63	–	–	3	5	–	1	–	4	1	5	3	12	3	36	86	19	41	3	32	15	1	1	–	290
Wakefield, . . .	19	–	–	–	–	–	–	7	–	–	–	–	–	–	–	14	5	18	16	8	6	–	4	–	36
WALTHAM, . .	45	–	–	–	4	–	4	1	1	–	5	–	4	3	7	39	11	49	36	15	19	–	–	4	83

Ware,	12	–	–	–	–	–	–	–	–	–	–	–	9	–	1	14	–	7	5	–	6	–	2	–	70
Watertown,	21	–	–	–	2	1	1	6	–	3	1	–	5	2	–	17	7	16	16	9	5	3	7	12	19
Webster,	21	–	–	–	2	1	1	2	2	–	–	–	6	3	–	18	1	8	2	2	4	2	1	–	84
Wellesley,	8	–	–	1	1	–	–	3	–	–	–	–	–	–	–	5	2	5	5	2	1	1	1	–	16
Westborough,	16	–	–	–	–	–	–	2	–	–	–	1	1	–	–	3	1	16	99	15	7	–	3	–	19
Westfield,	21	–	–	–	6	–	4	2	–	–	–	–	3	1	–	14	2	34	10	8	8	–	11	–	80
West Springfield,	11	–	–	1	2	–	–	4	1	–	–	–	5	–	1	11	2	10	–	14	1	–	4	–	45
Weymouth,	21	–	1	1	3	–	1	6	–	–	2	–	4	–	–	20	3	27	18	14	7	2	6	10	30
Whitman,	5	–	–	–	2	–	–	–	–	1	–	–	1	4	2	9	1	8	13	3	3	–	2	1	16
Williamstown,	7	–	–	–	–	–	–	–	–	–	–	–	2	–	–	2	4	7	4	1	2	–	3	–	28
Winchendon,	11	–	–	–	–	–	3	1	–	1	–	–	1	–	–	14	2	11	12	2	4	–	2	–	17
Winchester,	4	–	–	–	1	1	–	–	–	–	3	–	1	–	2	8	4	15	10	3	7	3	2	–	42
Winthrop,	3	–	–	–	–	–	1	–	–	–	–	–	–	1	2	6	2	10	8	10	6	2	5	5	5
WOBURN,	17	–	–	–	1	–	–	–	–	–	–	–	8	1	–	19	2	9	11	7	9	2	4	–	105
WORCESTER,	211	–	1	5	8	12	5	–	8	6	–	2	60	8	10	229	57	244	291	120	112	15	83	3	498
Totals,	4,234	8	165	113	628	119	420	297	154	70	203	30	1,374	166	947	4,181	1,117	4,276	3,315	2,175	1,938	273	1,357	448	12,742

Homicide.

Adams,	1
Andover,	1
BEVERLY,	1
BOSTON,	24
Brookline,	2
Franklin,	1
HAVERHILL,	1
Methuen,	1
NEWBURYPORT,	1
SPRINGFIELD,	3
Watertown,	1
WORCESTER,	5
	42

Anthrax.

LYNN,	2

Actinomycosis.

BOSTON,	1

Glanders.

CHELSEA,	1

Malignant Pustule.

BOSTON,	1
CAMBRIDGE,	1
	2

Tetanus.

Braintree,	1
PITTSFIELD,	3
SPRINGFIELD,	2
	6

Trichinosis.

SPRINGFIELD,	2

TABLE IV.

Deaths from Specified Causes, 1904, in Cities and Towns required to report to the State Board of Health, Death-rates per 10,000 (1900-1904), Deaths per 1,000 from All Causes, 1900-1904.

CAUSES OF DEATH.	Deaths. 1904.	MORTALITY PER 10,000 OF THE POPULATION.					DEATHS PER 1,000 FROM ALL CAUSES.				
		1904.	1903.	1902.	1901.	1900.	1904.	1903.	1902.	1901.	1900.
Consumption,	4,234	16.05	15.66	16.38	17.63	18.56	103.76	97.06	101.06	104.58	101.60
Smallpox,	8	0.03	0.08	1.12	0.39	0.008	0.20	0.51	6.89	2.30	0.046
Measles,	165	0.63	0.69	0.92	0.73	0.99	4.04	4.27	5.66	4.35	5.44
Scarlet fever,	113	0.43	1.75	1.13	1.46	1.51	2.77	10.85	6.99	8.64	8.29
Diphtheria and croup,	628	2.38	2.94	3.22	4.40	5.87	15.39	18.20	19.84	26.13	32.12
Whooping-cough,	119	0.45	1.64	0.96	0.84	1.27	2.92	10.19	5.96	4.99	6.85
Typhoid fever,	420	1.59	1.81	1.88	1.96	2.25	10.29	11.24	11.59	11.61	12.34
Cerebro-spinal meningitis.	297	1.13	1.33	1.39	1.46	1.63	7.28	8.23	8.60	8.69	8.91
Erysipelas,	154	0.58	0.35	0.44	0.47	0.66	3.77	2.16	2.74	2.79	3.66
Puerperal fever,	70	0.27	0.33	0.32	0.34	0.37	1.72	2.04	1.98	2.00	2.01
Influenza,	203	0.77	1.06	0.43	1.90	2.28	4.97	6.60	2.64	11.29	12.44
Malarial fever,	30	0.11	0.16	0.15	0.19	0.22	0.74	1.02	0.94	1.14	1.23
Cholera infantum,	1,374	5.21	5.89	6.05	6.11	9.87	33.67	36.50	37.36	36.28	54.10
Dysentery,	166	0.63	0.62	0.70	0.72	0.75	4.07	3.88	4.35	4.25	4.12
Diarrhœa and cholera morbus.	947	3.59	3.29	3.71	3.54	3.84	23.21	20.36	22.88	20.99	21.00
Pneumonia,	4,181	15.85	16.48	16.07	16.66	18.40	102.46	102.11	99.21	98.83	100.70
Bronchitis,	1,117	4.23	4.55	4.69	4.47	5.09	27.37	28.17	28.96	26.50	27.88
Diseases of the heart,	4,276	16.21	15.25	15.66	15.70	16.16	104.79	94.52	96.40	93.12	88.45
Diseases of the brain and spinal cord.	3,315	12.56	11.15	12.17	10.41	10.81	81.24	69.10	75.12	61.76	59.00
Diseases of the kidneys,	2,175	8.24	8.45	7.38	7.75	7.32	53.30	52.36	45.57	46.01	40.05
Cancer,	1,938	7.34	7.05	6.91	6.19	6.53	47.49	43.70	42.66	36.75	35.75
Suicide,	273	1.03	1.05	1.02	1.05	0.99	6.69	6.50	6.30	6.22	5.39
Accident,	1,357	5.14	5.43	5.40	5.39	5.20	33.25	33.66	33.31	31.95	28.50
Unknown or ill-defined causes.	448	1.70	1.91	1.64	1.77	2.63	10.98	11.84	10.11	10.52	14.38
All causes,	40,806	154.65	161.32	162.07	168.58	182.60	-	-	-	-	-

HEALTH OF TOWNS.

HEALTH OF TOWNS.

The following digest consists chiefly of extracts from the annual reports of the boards of health of cities and towns for the year 1904, illustrating the character and extent of the sanitary work performed by the local authorities.

One hundred cases of smallpox were reported for the year 1904, as against 417 for the year 1903 and 2,305 for the year 1902, showing a marked decrease in the prevalence of this disease.

There has been a decrease in the number of reported cases of scarlet fever for the year 1904, as compared with the number reported for 1903. The largest number of deaths from this disease occurred in Springfield (7 deaths in 129 cases), the fatality being 5.4 per cent. In Boston there were 966 reported cases and 39 deaths, a fatality of 4.0 per cent. In Cambridge, 135 cases with 3 deaths, the fatality being 2.2 per cent.; in Fall River, 102 cases with 2 deaths, the fatality being 1.9 per cent.; in Lowell the fatality was 4.2 per cent., in Somerville 2.5 per cent., in Worcester 2.1 per cent., while in Newton it was about 1 per cent.

Following the extracts from the reports of local boards of health will be found a table showing the visits and inspections made by the medical inspector of the State Board of Health, for the purpose of aiding local authorities in controlling the spread of smallpox.

The following numerical statement of bacteriological work performed by local boards of health is also taken from the annual reports of those boards for the year 1904: —

Bacteriological Work performed by Local Boards of Health and by the State Board of Health, 1904.

	Diphtheria Cultures.	Tuberculosis.	Typhoid Fever.	Malaria.	Packages of Antitoxin distributed.
Boston,*	9,237	3,115	1,164	134	–
Brockton,†	176	219	69	44	–
Brookline,	643	118	58	26	–
Cambridge,	1,438	267	275	–	–
Fall River,	289	–	147	–	–
Fitchburg,	63	93	46	–	–
Greenfield,	20	–	–	–	–
Holyoke,	378	–	–	–	–
Lowell,	1,339	257	131	7	–
Lynn,	937	–	–	–	–
New Bedford,	239	85	4	–	–
Newton,	66	–	75	–	–
Palmer,	37	–	–	–	–
Somerville,	1,429	124	76	–	–
Springfield,	1,431	19	–	–	–
Waltham,	228	27	–	–	–
Worcester,	1,328	422	–	–	–
State Board of Health,‡ §	1,014	494	204	24	22,255

* Glanders, 147; other diseases, 91.

† Other diseases, 56.

‡ Other diseases, 3.

§ Six months ending Sept. 30, 1904.

Amesbury.

After months of satisfactory conditions, a single case of scarlet fever was reported. About one week later 8 cases were reported in one day. So rapidly did it spread that in a few days the board found that they were grappling with the most extensive epidemic that had invaded the town for years. Upon investigation, it was found that nearly all of the first 30 cases followed in the track of one milk supply. It was thought best to ask the aid of the State Board of Health in determining the cause and the amount of quarantine regulations advisable. The State inspector was soon on the scene, and, acting in conjunction with the local board, visited not only this milk farm, but every case that had been reported at that date. It was learned that no scarlet fever had occurred at the farm for some years, and everything about the place was neat and clean. Further, it appeared that several cases of scarlet fever had occurred about town, of so mild a character as to be unrecognized. From these, and by that system of milk delivery practised within the past few years, of leaving individual receptacles which were supposed to be cared for by the householder, but which really received insufficient attention, the disease was transmitted broadcast. The owner of the milk route suffered a financial loss and injustice for that in which he was in no way responsible. The fault is in the system of distribution followed by him and others, which we heartily condemn, unless the producer is provided with, and will use, adequate means for sterilizing the bottles and cans.

The quarantine was not observed in all cases to the satisfaction of the board. They must perforce rely upon the attending physician to see that the details are enforced. Cases have come to our notice where members of the family have been allowed undue latitude, and even to resume work, before the process of disinfection had been complete. Every medical man should join his efforts with the board of health in the attempt to control this or any other of the dreaded diseases. Fortunately, the cases, numbering nearly 80, have been mild in character.

Beverly.

Such inspection of bakeries as is prescribed by law has been made. In a majority of cases these important places, where so much of our food product is manufactured, were found to be in a good general condition. Twelve bakeries are at present in operation in the city.

The steady growth of the city constantly increases the amount of garbage to be collected and gotten rid of. The collection of garbage the past year has been done by parties licensed by the board to collect in allotted sections of the city. The greater part of the amount collected has been disposed of outside of the city.

Boston.

The total number of deaths for the year was 10,757, an increase over the previous year of 125 deaths. The death-rate for the year, as calculated, is 17.50 per 1,000 inhabitants. This rate is less by .19 than that of the previous year, and the lowest on the city's record. There were 2,311 deaths from infectious diseases, including consumption, an increase of 19 deaths. There were 8 less deaths from diphtheria and croup than in 1903, but a large proportionate increase in the number of cases. The percentage of deaths to the number of cases of diphtheria reported was 8.12, as against 10.32 per cent. the preceding year. There were 39 deaths from scarlatina, 26 less deaths than in the preceding year, and 84 deaths less than the average for the five previous years. Typhoid fever caused 135 deaths during the year, 16 more deaths than the preceding year. The respiratory diseases caused fully 27 per cent. of the mortality for the past year.

Disinfection, 1904, — Materials used.

Formaldehyde,	1,860 gallons.
Alcohol (for heat),	785 gallons.
Chloride of lime,	49,000 pounds.
Bichloride of mercury,	875 pounds.
Chloride of sodium (in mixing),	1,050 pounds.

Medical Inspection of Schools. — Summary.

Specific infectious diseases,	516
Oral and respiratory diseases,	1,318
Diseases of the ear,	123
Diseases of the eye,	714
Diseases of the skin,	3,985
Miscellaneous diseases,	3,743
Found free from disease,	5,753
Total,	16,152
Number of pupils examined in the schools,	16,152
Number recommended to be sent home,	3,259
Number consultations with teachers (about pupils returning to school, etc.),	2,372

Contagious Diseases. — The reduction in the mortality from diphtheria since 1895 has been due principally to the extensive use of antitoxin and skilful intubation, both in hospital and in the homes. The average annual percentage of mortality to the total number of cases of diphtheria for ten years prior to the use of antitoxin in 1895 was 35.66 per cent. The percentage of mortality since 1895 has been 11.53 per cent. No case of smallpox was found in this city during the calendar year ending Dec. 31, 1904. If simple isolation and disinfection have been responsible for the greatly diminished morbidity and mortality from scarlet fever in Boston since 1877, they have been more effective than in any other infectious disease in our city. Smallpox alone has been diminished as much, but in that disease we have the advantage of vaccination, which supersedes all other measures. The annual mortality from scarlet fever for ten years previous to 1877 averaged 317, and for the twenty-eight years since it has averaged 116. The average annual number of deaths from smallpox in Boston from 1840 to 1873 inclusive was 86.7, and from 1874 to 1904 inclusive 10.9.

Milk Inspection. — The condition of the milk sold in Boston has as a whole proved satisfactory, and the number of prosecutions was not materially larger than for the preceding year. During the summer months it was found that some of the cream upon the market was being preserved by the use of sodium benzoate. A large number of samples were collected, and subjected to analysis. This resulted in the conviction, with substantial fines, of four sellers of the cream, and the stopping of further use of this preservative. The employment of other preservatives and of coloring matters in milk has been reduced to a minimum. A number of contractors have issued circular letters to the farmers whose milk they purchase, explaining the necessity of proper methods of milking, cooling and storage; and it is their intention, in making new contracts, to provide that the milk sent to Boston shall have been produced under conditions approved by the board of health.

The total number of samples collected and examined was 18,846, as follows: —

Number of samples of milk from wagons,	6,812
Number of samples of milk from stores,	6,499
Number of samples of milk brought in by citizens,	169
Number of samples of milk (bacteriological),	3,300
Total milk samples,	16,780
Number of samples of vinegar,	603
Number of samples of butter, cheese and oleomargarine,	1,463
Total samples,	18,846

Stables. — Hearings were had on fifty-two applications for the occupation of stables, with the following result: —

Granted,	34
Refused,	10
Awaiting action,	5
Withdrawn,	3

Examination of Plumbers. — During the past year weekly examinations have been held by the board of examiners of plumbers. Of the number who applied for masters' licenses, 31 passed satisfactory examinations and were granted licenses and 43 were refused, not having passed satisfactory examinations. Of those who applied for journeymen's licenses, 50 were granted and 74 refused.

Dumps. — The growth of the city, and with it the enormous increase of waste matter to be gathered up and so disposed of as to prevent its becoming a source of annoyance and sickness, call for greater care in its disposal. The board respectfully begs to refer again to its recommendation in its annual report of 1895 for the systematic burning of this waste material in several sections of the city, and at moderate cost, to abate one of the great sources of annoyance and complaint throughout the city.

Poultry. — In October the board passed the following regulation respecting the killing and keeping of poultry: —

> *Voted,* That no live chickens, geese, turkeys, ducks or other fowls shall be brought into or kept or held or offered for sale or killed in any place in the city of Boston without a permit therefor in writing from the board of health, which permit shall be subject to revocation by said board at any time; and it is further
>
> *Ordered,* That no carcass of poultry shall be plucked in said city except in such places as are now or may hereafter be assigned by said board for said purpose; and it is further
>
> *Ordered,* That no carcass of unplucked poultry shall be brought into or exposed or offered for sale or sold in said city.

Bacteriological Laboratory. — Plans were made and approved in the early part of the year for the removal of the laboratory to a new location on Boylston Street, and on Aug. 29, 1904, the transfer took place. No interruption of the routine work was permitted, but special investigations were much hampered, and, in most instances, abandoned. The most satisfactory feature, from the executive standpoint and the standpoint of the physician, has been the introduction of a new device, original with the director of the laboratory, for the delivery of cultures directly into an incubator. This device is available to a messenger from the physician at any hour after the laboratory closes at 6 P.M. About one hundred cultures per month have arrived in this way, all of which would have been delayed about thirty-six hours under the old methods.

Special work in the line of new devices was as follows: porous tops for Petri dishes; method for preparing specimens for staining flagella; staining bath for Gram's method; a method of preparing dialysing membranes; a new form of water-pressure filter for toxins, mallein, etc.

This laboratory now acts as a depot for the distribution to physicians of vaccine and antitoxin made by the Massachusetts State Board of Health, and supplies mallein, made in this laboratory, to veterinarians.

Inspection of Animals. — The inspector of animals reports 76,777 animals slaughtered at the abattoir. One hundred and thirty-one animals, weighing in the aggregate 11,880 pounds, were condemned.

Twenty-eight cases of actinomycosis were found. Tuberculosis was found in 282 cattle and 2 swine.

The inspection of cattle kept for the production of milk within the city limits has been continued as heretofore. Five animals were found tuberculous, and quarantined. Six cases of actinomycosis were found in cows kept for the production of milk.

Suspicious cases of glanders among horses to the number of 292 have been reported to the board of health, of which 212 were found to be infected.

Six cases of suspected rabies have been reported to the board, one of which proved to be a case of rabies, which was brought to one of the veterinary hospitals in this city from Somerville.

BROCKTON.

In praise of the work of the bacteriological department, and of its importance, too much cannot be said. During the past year nearly 600 examinations have been made for the physicians of the city; for diphtheria, 115, of which only 28 were found positive, thus relieving many households (in some cases several in a house) from quarantine, which a clinical examination might have required, and which imposes a great and sometimes unnecessary hardship. We are pleased to state that this branch of our department is receiving the most hearty commendation, not only from the physicians of the city, but from many citizens who are acquainted with the work it is accomplishing.

Antitoxin has been supplied freely, and the confining of the disease to the one sick, in families where there were several children, we believe is due to immunizing with 500 unit injections the other members of the families, — a practice which the board insists shall be adopted by all physicians just as far as possible. We also believe the low death-rate is due in a measure to the free use of antitoxin as quickly as possible, whenever and wherever a clinical examination indicates diphtheria to be present.

BROOKLINE.

There were 66 persons admitted to the hospitals for contagious diseases, 1 more than last year. The maintenance of the hospitals has cost considerably less than last year, largely because there were a good many exceptional expenditures last year before the hospitals were in thorough working order. There have been some further expenses of the same kind this year and some repairs; also one of the old wooden buildings has been extensively fitted up and improved.

Much has been done in the way of filling up or draining off unnecessary pools of standing water which were affording breeding places for mosquitoes, and water which could not be drained off has in many cases been petrolized, particularly in the street catch-basins. A good many landowners are disposed to co-operate willingly, either doing the work themselves or paying the cost of it, but there are still some who have done little or nothing. There are fewer people than there were who believe that mosquitoes can be wholly exterminated in a single season, but there is an increasing number who think that much good will be accomplished by the work that is being done.

The need in this neighborhood of more adequate hospital accommodations for poor patients in the advanced and most infectious stage of consumption is still very great. It is practically impossible for a consumptive in the latter stages to live in a boarding-house or tenement without being a real menace to the health of those about him.

From Feb. 1, 1904, to Jan. 31, 1905, the disinfector for the board disinfected with formaldehyde and corrosive sublimate solution, or formalin, as follows: 61 rooms and 11 bath-rooms after 30 cases of diphtheria; 46 rooms and 6 bath-rooms after 34 cases of scarlet fever; 24 rooms after 23 cases of tuberculosis; also the 3 bath-rooms, basements, hallways and elevators of two apartment hotels after a case of the latter disease; 1 room each after fatal cases of typhoid fever, erysipelas and cancer; and 145 library books. He has also disinfected, upon recommendation of the attending physician, after 2 cases of measles, 2 of diphtheria exposure, 1 of tuberculosis, 1 of typhoid fever, and a quantity of clothing, books, etc., all of which was paid for by the parties for whom the work was done, when able to pay for it, if not, it was done at the expense of the health department.

Every milk wagon has been examined, and, when necessary, suggestions have been made as to the proper arrangement of boxes and compartments and the packing of milk bottles, with a view to prevent unnecessary noise, as well as to prevent contamination of milk and receptacles by contact with dirty cans, blankets, etc. A special circular on this subject was issued to milkmen August 1. Pressure has also been brought to bear upon owners of defective and noisy wagons, also upon noisy drivers, thereby stopping much unnecessary annoyance from this source.

Cambridge.

The most pressing need from the standpoint of preventive medicine is, and for years has been, a hospital with ample accommodations for cases of diphtheria, scarlet fever and measles. At the present time the diphtheria hospital can, when every bed is occupied, accommodate 19 patients. The Cambridge Hospital can accommodate, without overcrowding, 8 cases of scarlet fever. There is no place for the reception of cases of measles. This is a condition of affairs not creditable or humane in a city of 100,000 inhabitants. In case of a great outbreak of one of the diseases mentioned above, the board of health would be heavily handicapped in any effort to limit the spread of that disease, as the most efficacious method for such limitation is the prompt isolation in hospital of the early cases. Though the outbreak of an infectious disease may not be attended by a large fatality, the amount of privation and misery it may entail on the poor is not easily to be estimated.

During the year the inspector of provisions believed it advisable to recommend to the board the passage of a regulation which would prevent exposing for sale, outside of stores or shops, meat, poultry, game or fish, and require the taking of proper precautions to prevent the accumulation of dust on the food so exposed, and also to ensure the preservation of the goods in warm weather. The good results received from the regulation which was passed by the board would make it seem advisable to include in a similar prohibition the method of selling dates and figs. At the present time these articles are often kept on stands outside of stores, and are exposed to any accumulations of dust or filth that may be blown about by the winds. It does not seem probable that food thus exposed is fit for consumption.

Medical Inspection of Schools. — The diseases discovered in the schools and the number of cases were as follows: —

Chicken-pox,	9
Measles,	16
Mumps,	21
Whooping-cough,	3
Pediculosis,	191
Diseases of ear,	24
Diseases of eye,	67
Diseases of nervous system,	12
Diseases of skin,	156
All other diseases,	217
Total,	716

CHICOPEE.

In cases of typhoid fever, investigations were made and information sought relative to the sources of water, ice and milk with which the patients were supplied during a period of two months ending with date of illness, in order to determine, if possible, where and how the disease was contracted. Several cases were reported, the causes of which were traced outside of the city.

FALL RIVER.

The number of cases of scarlet fever, diphtheria, typhoid fever, smallpox and all contagious and preventable diseases, reported for the year, are small compared with that of any previous year or with that of other Massachusetts cities as compared with the population.

This condition is due, in the opinion of the members of the board, to the vigorous action taken in 1903, during the prevalence of the smallpox and typhoid fever outbreaks, when stringent measures were taken to stamp these diseases out, and keep them out if possible.

First. — By excluding milk from sale in the city from any suspected source, until satisfied beyond the possibility of a doubt that it could not convey the germs of any disease.

Second. — By assuming, under the rules of the State Board of Health, with the consent of the Watuppa Water Board, jurisdiction over the source of water supply of the city, to prevent the possibility of any pollution or contamination of the water of North Watuppa Pond and its tributaries by householders or in the harvesting of ice, and by prohibiting skating, boating, fishing, bathing, and washing clothes in the water, or holding picnic parties on the shore thereof. This has met with the almost unanimous approval of our citizens, including those who previously enjoyed the pastimes prohibited, and about the only criticism heard was surprise expressed that those precautions had not been taken years ago.

Third. — By a general vaccination in all the public, parochial and private schools in the city and the districts where smallpox appeared.

Fourth. — By a general medical inspection of all the schools in the city, and the fumigation that followed in schools and dwelling-houses supplemented by the sanitary inspections afterwards made and the subsequent cleaning up of premises found in need of it, which produced the best sanitary conditions obtained in the city for a number of years.

By an order adopted by the board a year ago, the vaccination of all persons is made compulsory under the provisions of the Public Statutes of the Commonwealth, and a certificate of successful vaccination is required as a prerequisite to entering any school in the city, with the result that there is practically no pupil attending any public or private school in the city who is not vaccinated or in possession of a certificate of exemption according to law under the regulation of the board of health.

Thorough vaccination is the best known preventative against the spread of smallpox if it should again appear, and there is, perhaps, no community more thoroughly fortified against the invasion of this disease, in this way, than the city of Fall River. 1,723 persons were vaccinated under the order above referred to during the past year.

Fitchburg.

In February, 1904, the board strengthened the efficiency of the quarantine regulations by passing the following votes: —

Voted, That rules 13 and 14 of the rules and regulations of the board of health shall apply to Sabbath schools and church services.

Voted, That the pastors and Sunday-school superintendents of the city be notified to the above effect.

By so doing, pupils in all the schools of the city are now placed under the same restrictions during the period of quarantine. Several superintendents of our Sunday-schools have expressed satisfaction on account of the advanced step taken in these matters by the board. As a result of this vote, whenever a scholar in any school is reported sick with a contagious disease, the superintendent of the Sunday-school which the scholar attends is notified of the fact, as well as the teacher in the day school, and the said scholar is not allowed to attend either public school or religious services until released from quarantine. At the same meeting the board adopted rules to be observed during quarantine, and to be posted in or near the door of the sick room.

The inspection of the houses in which occurred the 42 cases of diphtheria, croup, scarlet fever and typhoid fever, during 1904, showed the plumbing to be in poor condition in only one instance in a case of diphtheria and in one of typhoid fever. This bears out the previous observations of the board in regard to the relation of plumbing to contagious and infectious diseases.

HAVERHILL.

The routine work of the department has been similar to that of the previous years. There are not so many complaints of vaults and cesspools as there were a few years ago, and less unsanitary plumbing. Practically all the privy vaults (1,679 in all) and cesspools in sewered streets have been abolished, and water-closets with sewer connections have taken their place. The plumbing and house sewerage systems in fully two-thirds of the buildings in the city have been reconstructed and modernized since the passage of the plumbing ordinance.

HOLYOKE.

The board would once again call attention to the imperative need of a hospital for the care of diseases of a contagious nature, especially diphtheria and scarlet fever. The value of such institutions is being realized more and more each year, and many cities of the State now have such accommodations, which greatly aid in the control of epidemics of such diseases. With our large tenement districts, it is evident that we should have such a building at our command in the city.

The present pest-house in use by the city is well suited in most ways, and furnishes a very satisfactory as well as secluded place of confinement for persons suffering with smallpox. Improvements recommended last year should be made. A sanitary system should be arranged to remove the sewage from the building, and a satisfactory receptacle made for the same. A small addition should also be made to include a disinfecting room for those who are obliged to visit the building, and also a bath-room for the use of patients. These necessities are indispensable, and should receive immediate attention.

LEOMINSTER.

The board has hired a small room centrally located, and has begun fitting it up for laboratory work, has purchased many utensils and articles needed for its equipment, and will proceed to still further equip it as fast as it is needed.

We hope within a short time to have this equipped and a competent man installed who will be at all times available, so as to be able to fully examine any specimen left there by any physician in town, and the result given within a short time.

LOWELL.

For failure to comply with the requirements of the statutes of the Commonwealth and the regulations of the board of health in regard to the burial of the body of a person dying with a contagious disease, an undertaker's license was revoked for one month. The particular offence was allowing a public funeral and permitting four young boys to act as bearers, in a case where the deceased died with diphtheria.

For allowing the father, who himself had diphtheria, to go in a public carriage to the cemetery for the burial of his child who had died with diphtheria, another undertaker's license was revoked for fifteen days.

These penalties were exacted for disciplinary purposes, the board feeling that the undertakers were becoming too careless concerning their responsibilities in preventing the spread of contagious diseases.

LYNN.

During the year 1904, from January 1 to December 31, there were admitted to the contagious disease hospital 83 cases of diphtheria and 25 cases of scarlet fever. One case in addition to the above mentioned was successfully treated for a complication of scarlet fever and diphtheria. There were no deaths from scarlet fever.

We now admit to the hospital patients suffering from erysipelas, who, for any reason, cannot be treated at home.

One thousand and sixty bottles of antitoxin, each containing 1,500 units, have been used in the treatment of diphtheria patients at the hospital during the year. Forty-six bottles have been used outside of the hospital for immunizing purposes.

Since the establishment of the laboratory, which enables us to determine with absolute certainty the quality of any given sample of milk, and whether it has been watered or adulterated in any way, frequent examinations have been made of the milk sold by our dealers and milkmen. Every store has been visited several times during the year, and samples taken for analysis. The milkmen are intercepted on their routes, and samples taken nearly every month. Should occasion require, samples are taken immediately, and in each case a copy of the analysis of the chemist is furnished to the dealer or milkman, so they may know just the quality of the milk. Frequent inspections have been made of the dairies and milk rooms, especially in regard to their cleanliness, and also in respect to sanitary condition. During the year 348 visits have been made, and such information as was necessary given as to changes which should be made.

MALDEN.

The wisdom of the medical inspection of the public schools has been proved by the small number of the graver contagious diseases that have occurred during the year. All the schools are at present under sanitary supervision, and the board feels that the small expense for that work is justifiable. Over 1,300 suspected cases were examined by the physicians, and many excluded from the schools, thus preventing further contagion.

During the year the city government has voted for the erection of a contagious hospital, and we hope when it is in working order for a still further reduction in the number of contagious diseases.

NEW BEDFORD.

During the year, in compliance with statutory requirements, an isolation hospital has been erected. It should be equipped at once, and placed in readiness for the reception of patients. The board feels that the city is to be congratulated upon the possession of a hospital for the care of patients afflicted with diphtheria or scarlet fever, who, living in boarding-houses and large tenement blocks, endanger others, oftentimes being the means of causing epidemics of those diseases. We believe its usefulness will be better appreciated as the people become better acquainted with its conveniences, situated as it is in a most healthful locality, with an abundance of pure air.

NEWTON.

In the matter of free examination of specimens of sputum for the detection of tubercle bacilli, the recommendation of the department was reported upon favorably by the finance committee and passed by the board of aldermen. The department promptly prepared the necessary outfits for collecting specimens, and notified the physicians of the city that they could be obtained at the various culture stations after Jan. 1, 1905.

The department considers this a distinct step in advance, and one which helps to keep abreast of the steady advance in health work.

Too much stress cannot be laid upon the necessity of early treatment in diphtheria, as the mortality is in direct proportion to the delay in beginning treatment. With the exception of these cases, there was nothing remarkable about the occurrence of the disease during the year.

Milk Farms. — All milk farms in the city where more than seven cows are kept for the purpose of producing milk for sale have been inspected monthly by the agent, and smaller farms have been inspected at frequent intervals. Most of the milk used in the city is produced on farms outside of the city limits, and the sanitary condition of many of these farms is far from satisfactory. No regular inspection of such farms is made by this department, and in some near-by communities there is a total lack of local oversight. This condition suggests the necessity of some general law providing for the supervision and control of milk producers.

The occurrence of suspicious cases of typhoid fever on the route of a dealer selling milk produced outside the city is always made the occasion of an examination of the producer's premises; and in this manner dangerous conditions have several times been discovered, and improvements insisted on in cases which would not otherwise come within the jurisdiction of this board.

NORTH ADAMS.

In the regular routine of the work of the board there have been made during the year 637 quarantine inspections and fumigations, 69 milk inspections and 763 general inspections of houses and premises. Besides these, some hundreds of special inspections of houses and persons were made by the chairman and the physician of the board during the months from August to October inclusive.

The board would call attention to the marked diminution in the typhoid fever cases occurring in the city during the two years of office of the present board, the number for 1904 being 31. It was for the purpose of eradicating this disease from our city that we employed a physician to the board.

NORTHAMPTON.

In March the attention of the board was called to the condition of the Robert's meadow water-shed. It was found that several farmhouse privies in this area drained almost directly into brooks which are part of Northampton's water supply, and that at one of these places a case of typhoid fever had recently occurred. At the request of this board the State Board of Health made regulations to prevent the pollution of Northampton's water supply, and, acting by the authority of these rules, the board of water commissioners have greatly improved matters; but Northampton will never be entirely free from the danger of typhoid epidemic until certain farms have been bought by the city.

PITTSFIELD.

We would recommend that the city consider the question of erecting some small building for the treatment of contagious diseases. The city is called upon to care for many cases of diphtheria, smallpox and scarlet fever, by reason of a lack of means in the families of the patients. Maintaining an effective quarantine is often difficult, and the expense of food, medicine and repayment for articles necessarily destroyed when quarantine is raised is often large. We think that a small detention building would prevent the spread of contagion, and enable the city to handle its cases at less expense.

Provincetown.

The past year has been a very favorable one as regards the health of the community, a very few cases of contagious diseases having occurred. A number of cases of diphtheria were reported, and the dwellings wherein the cases occurred were promptly placed under quarantine. The local physicians attending the same were furnished with culture tubes and antitoxin received from the State Board of Health, so that the disease, which at one time threatened to become epidemic, was stamped out, and all danger for the time being was averted, no case proving fatal. No other contagious disease has been reported to us during the past year.

Quincy.

This year, as in past years, the board has endeavored to carry out the work of improvement of the city's sanitary condition through the enactment and enforcement of the rules and regulations. Having that object in view, our efforts have been rewarded in a measure, and we note with satisfaction a decrease in contagious diseases over previous years. The number of cases of infectious diseases reported to the board of health the past year has been less than in the previous year. The death rate, based on the estimated population, has been 12.57 per thousand, as against 13.51 in 1903.

Rules regulating barber shops have also been enacted, copies of which have been posted in every shop, that the public may know what is required from barbers in the way of cleanliness and hygiene.

The collection of garbage has been done in as satisfactory a manner as could be expected, with the limited means at hand. The various locations known as "dumps" have been inspected at intervals and kept free from nuisance.

The bakery shops have also been inspected, and made to comply with the statutes as much as practicable.

The following licenses were issued by this board in 1904: plumbers, 32; undertakers, 6; scavenger, 1; garbage, 30.

Salem.

During the year the board visited Hyde Park, and, after inspecting their system of collecting swill in metal barrels, caused a team to be put on for the same purpose in Salem. The idea promises to solve much of the trouble about unloading upon the city dump, and will for most of the year (except ing very cold weather) be a good thing. A second team is now being similarly constructed, and two horses have been purchased.

In the city there are 24 bakeries, large and small, 25 per cent. of which are considered by the inspector of the board as not fit places for the manufacture of food; another 25 per cent. are in fair shape, and the balance in good condition. According to the conditions as a whole throughout the city, a beginning was made none too soon to bring about proper sanitary conditions in these places. Even now, after a number of warnings, some of the bakers have not tried to any extent to bring their places within the scope of the statute. There is much difficulty for some of them to literally comply with the law, because they are located in cellars, or in old and dilapidated buildings that are practically beyond repair. These places, unless radically changed, should be condemned, and the proprietors compelled to locate in more suitable buildings.

SOUTHBRIDGE.

In common with many other towns and cities of the State, we have had an epidemic of diphtheria during the season. One hundred and eighty-six cases have been reported, with 18 deaths. It is significant that more than two-thirds of the fatal cases were those who had no medical attendance, or in which a physician was not called until the patient was beyond help. It is practically certain that, had these cases been reported promptly, a number of valuable lives would have been saved. We hope the public will more and more realize the need and value of sanitary work, and give the board its hearty assistance in its efforts to render the town clean and free from contagion.

SPRINGFIELD.

More important, probably, than the laboratory examination of milk, is the oversight of the conditions under which milk is produced at the farm. It is the intention of the board to take every precaution to exclude from the city milk that is not produced under safe conditions, to say the least, and to very greatly improve the conditions as to cleanliness in all things relative to the actual collection and care of the milk before and after it is brought to the city.

Medical Inspection of Schools. — The board of health has been in favor of the medical inspection of schools in this city for a long time, and has known of the interest of the school board in this connection. The matter has been agitated recently, and it is hoped that arrangements may be made the coming year so that either this board or the school board may be enabled by the means of a suitable appropriation to take up this important work. During the last few months case after case of illness of one sort or another has been referred to the board of health office or to the health physician by school teachers, for diagnosis, treatment and advice. While the board does not consider that the ordinary contagious diseases are spread by means of the school, personal visits to the schools show that there are cases constantly coming to the teachers' notice which demand medical advice. Contagious skin diseases are not at all uncommon in the schools, and the teachers cannot be expected to promptly or properly realize the nature of these affections.

During the latter part of the week ending December 24, several cases of scarlet fever were reported from the upper residential portion of the city. Investigation showed that the families in question took milk from the same milkman. It should be stated at this point that the last known case of scarlet fever in this city previous to this was that of a small child who was removed to the isolation hospital from a tenement house in one of the poorer portions of the city on November 22. This child had recovered and been sent home before the outbreak in question began. There was, therefore, so far as known, no scarlet fever in the city at the time of this outbreak, nor could it be connected in any possible way with the case just described. Investigation also showed no cases of illness among those having to do with the milk on this route. Cases continued to be reported, however, during the succeeding week, and a further investigation was carried on, taking the form of a personal inspection of the hands and feet of those having anything whatsoever to do with handling the milk. The milk cans were washed at a place other than where the milk was produced, and no sign of any contagion was found at this point. The dairy was found to be in excellent condition, managed by a firm much interested in keeping their place neat and clean. No cases of sickness were found here, but the last person to be examined, a young man of about twenty-three, showed peeling on the hands and feet. Careful questioning brought about the facts that about the first of December this man had a sore throat for two days, but during this time he kept at work, missing none of his meals, nor did he confess to having been sick in any other way. This man was then sent to the isolation hospital, where he remained four weeks, desquamating freely. The dairyman, although somewhat skeptical at first that this was the cause of the infection among his customers, was soon convinced of the truth of the matter, and did everything in his power to assist the board of health in preventing further spread of the disease. He marketed no milk, by order of the board, from December 29 until January 13, a period of fifteen days, and during this time the dairyman's house was thoroughly fumigated, all the barn implements and utensils used in connection with the milk washed in hot water and disinfected, the stable whitewashed and the cows washed twice.

In all 31 cases of scarlet fever occurred in families taking milk from this one dairyman, these cases being reported between the dates of December 20 and January 3. The disease subsided very promptly after the supply of milk from this source was stopped, and during this period of two weeks but one other case of scarlet fever not on this route was reported, and that seemed to be a case secondary to the one already reported. The disease in each case ran a comparatively mild course, but there was a marked degree of peeling in many cases. No fatalities resulted. The average period of isolation was five weeks.

A consideration of the number of families served by this dairyman showed that, of the total number of cases of scarlet fever at this time, there were six families in which more than one member was attacked. It appeared that most of the families affected were served with the morning's milk. This fact cannot but suggest the possibility of a rather hasty toilet in the morning before proceeding to milk the cows. In conclusion, it seems evident that the cause of this scarlet fever epidemic was due to the use of milk unmistakably infected by the milker milking with freely desquamating hands.

Waltham.

A general inspection of the dairies in this city and of several of those in neighboring towns from which a portion of our milk supply is derived has been made during the year, and, while the conditions surrounding the production of this important article of food were found to be reasonably satisfactory, yet there is room for improvement.

In several places milk is stored in rooms within or adjoining the cow barn, where, during the process of cooling and until tightly sealed within the cans for delivery, it is exposed to the prevailing atmosphere of the barn. As milk is known to be a ready absorbent of gases, it should be removed as soon as drawn to an atmosphere as nearly pure and free from all odors as the most sanitary surroundings will produce.

Watertown.

Much work has been done during the past season in cleaning up stagnant pools, ponds and brooks. In this connection the Board gave its attention to the suppression of the mosquito nuisance. There are in the town some fifteen ponds, large and small, which were cleaned up and treated with crude petroleum. In addition to the ponds, the catch-basins connected with the drainage system were treated several times. These are prolific breeding places for the mosquito during the warm months.

Worcester.

The good work of the isolation hospital has continued during the past year. Last year we reported the remarkably low mortality rate of 3.8 per cent. for diphtheria treated at the hospital. This year we have great pleasure in reporting that the rate of mortality has been reduced to 1.4 per cent.; that is to say, of 67 cases treated, many of them severe, only 1 died.

Proportion of Cases reported in the City which were treated at the Hospital.

	Diphtheria (Per Cent.).	Scarlet Fever (Per Cent.).		Diphtheria (Per Cent.).	Scarlet Fever (Per Cent.).
1897,	20.80	7.00	1901,	33.80	28.89
1898,	23.90	9.70	1902,	46.25	21.68
1899,	29.70	17.70	1903,	46.33	20.23
1900,	38.30	27.20	1904,	61.49	28.57

Mortality Rate for Diphtheria, by Years.

1897,	8.57	1901,	7.77
1898,	8.69	1902,	5.79
1899,	7.20	1903,	3.84
1900,	8.00	1904,	1.49

The gradual drop in our mortality rate for diphtheria, as shown in the above table, is very gratifying. It also signally proves the great value of antitoxin, for, while all other conditions and methods of treatment have been practically unchanged during these eight years, the death-rate has decreased in direct ratio to the increased dosage of serum. We believe that the conditions which exist here for demonstrating the efficacy of the remedy are particularly good, and make the statistics valuable, even though the numbers treated are not great.

In the first place, the patients are placed under ideal hygienic conditions made possible by the situation of the hospital. Sunlight and fresh air are unrestricted. Then all local treatments, which harass and exhaust the patients, are abandoned, and we simply rely upon the serum to combat the disease. During convalescence patients are guarded by rest in bed and a restricted diet until nature has had time to repair the injured tissues. We emphasize this treatment because of the unfortunate prejudice which seems to still exist in the public mind against antitoxin. The average dosage per patient the past year has been 11,085 units. The largest amount any one person received was 42,000 units, and was given in 6,000 unit doses every six hours. Three thousand units was the minimum amount. Rashes of greater or less severity were very common during the first part of the year, but during the last three months scarcely any have been seen. These are due, we believe, to the irritating properties of one particular lot of serum. The only death from diphtheria was due to pneumonia complicating the disease in an infant one year old.

Record of Visits made to Cities and Towns by Dr. Frank L. Morse, Medical Inspector, for the Purpose of investigating 51 Cases suspected of being Smallpox during 1904.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully vaccinated.	Remarks.
1	Lawrence, .	Jan. 6,	M.	12	Discrete, .	No, ...	Ill January 2. Eruption January 5. Eruption in papular stage.
2	Lawrence, .	Jan. 11,	M.	25	Discrete, .	No, ...	From Somerset, Vt., where smallpox existed December 27. Ill January 7. Eruption January 9. Eruption in papular stage.
3	Maynard, .	Jan. 16,	M.	6	–	Two years ago.	
4	Maynard, .	Jan. 16,	F.	8	–	Two years ago, .	Diagnosis, chicken-pox.
5	Lawrence, .	Jan. 28,	M.	28	Discrete, .	January 14, . .	Exposed by case No. 2, January 10, 11. Ill January 22. Eruption 25th. Eruption in vesicular stage.
6	Newburyport, .	Jan. 29,	M.	27	–	Two years ago, .	Diagnosis, chicken-pox.
7	Lee, . . .	Feb. 8,	M.	2	Confluent,	No, ...	Ill January 29. Eruption 30th. Eruption in pustular stage. Infected by a case from Hudson, N. Y., who was taken ill on January 15. Died 22d.
8	Lee, . . .	Feb. 8,	M.	6	Discrete, .	No, ...	Ill January 29. Eruption 30th. Eruption in crust stage. Infected by a case from Hudson, N. Y., who was taken ill on January 15. Died 22d.
9	Lee, . . .	Feb. 8,	F.	30	Discrete, .	No, ...	Ill January 28. Eruption 30th. Eruption in crust stage. Infected by a case from Hudson, N. Y., who was taken ill on January 15. Died 22d.
10	Milford, . .	Feb. 19,	F.	16	Discrete, .	No, ...	Ill February 10. Eruption 13th. Eruption in pustular stage.
11	Milford, . .	Feb. 19,	M.	41	Discrete, .	Infancy, . . .	Ill Dec. 28, 1903. Eruption 29th. Remains of smallpox eruption on face and body.
12	Milford, . .	Feb. 19,	M.	4	Discrete, .	No, ...	Ill January 10. Remains of smallpox eruption on face and body. Unrecognized case.
13	Milford, . .	Feb. 19,	F.	14	Discrete, .	Four years ago, .	Ill January 15. Remains of smallpox eruption on face and body. Unrecognized case.
14	Milford, . .	Feb. 19,	M.	20	Discrete, .	No, ...	Ill January 20. Remains of smallpox eruption on face and body. Unrecognized case.
15	Wellesley, .	Feb. 25,	F.	21	–	Fourteen years ago,	Diagnosis, chicken-pox.
16	Hopedale, .	Feb. 26,	M.	16 months,	–	No, ...	Diagnosis, scarlet fever.
17	Hopedale, .	Feb. 27,	F.	33	–	Infancy, . . .	Diagnosis, erythema multiform.
18	Chester, . .	Mar. 1,	F.	17	–	Ten years ago, .	Diagnosis, chicken-pox.
19	Chester, . .	Mar. 1,	M.	26	–	Eleven years ago, .	Diagnosis, chicken-pox.

Record of Visits made to Cities and Towns by Dr. Frank L. Morse, Medical Inspector, for the Purpose of investigating 51 Cases suspected of being Smallpox during 1904 — Concluded.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully vaccinated.	Remarks.
20–25	Randolph,	Mar. 4,	M., F.	2–14	–	– –	Diagnosis, scabies.
26	Fall River,	Mar. 21,	F.	14	–	Two years ago,	Diagnosis, rheumatism.
27	Pittsfield,	Mar. 24,	M.	45	Discrete,	No,	Ill March 12. Eruption 14th. Eruption in crust stage.
28	Lowell,	Mar. 28,	M.	7	Discrete,	No,	Ill March 21. Eruption 24th. Eruption in vesicular stage. Father ill with smallpox from March 7 to 21.
29	Pittsfield,	April 9,	M.	22	Discrete,	No,	Exposed to case No. 27 on March 19. Ill March 31. Eruption April 3. Eruption in pustular stage.
30	Lynn,	April 29,	M.	9 months,	–	No,	Diagnosis, chicken-pox.
31	Leominster,	May 1,	F.	34	Discrete,	No,	Ill April 21. Eruption 25th. Eruption in pustular stage.
32	Marlborough,	May 6,	M.	9	–	– –	Diagnosis, scabies.
33	Watertown,	May 7,	M.	27	–	Two years ago,	Diagnosis, chicken-pox.
34	Monroe,	May 20,	F.	30	Discrete,	Infancy,	Landed at New York from Harve May 2. Ill May 10. Eruption 14th. Eruption in pustular stage.
35	Natick,	June 6,	M.	25	–	Two years ago,	Diagnosis, chicken-pox.
36	Lawrence,	June 8,	M.	25	Discrete,	No,	Ill May 31. Eruption June 4. Eruption in pustular stage.
37	Lawrence,	June 20,	M.	35	Discrete,	Twenty years ago,	Ill June 12. Eruption 15th. Eruption in vesicular stage.
38	Lanesborough,	June 22,	M.	18	–	No,	Diagnosis, chicken-pox.
39	Dedham,	June 23,	F.	19	–	Infancy,	Diagnosis, impetigo contagiosa.
40	Fitchburg,	July 8,	F.	28	Discrete,	Sixteen years ago,	From Canada July 1. Eruption July 2. Eruption in crust stage.
41	Fitchburg,	July 18,	F.	2	Discrete,	July 6,	Vaccinated after exposure to case No. 40. Eruption in pustular stage with no constitutional disturbance.
42	Lowell,	July 22,	M.	33	–	Infancy,	Diagnosis, erythema multiform.
43	Lawrence,	Aug. 12,	F.	15	Discrete,	No,	Ill July 29. Eruption August 2. Eruption in crust stage.
44	Lawrence,	Aug. 12,	M.	28	Discrete,	No,	Ill July 9. Eruption 13th. Remains of smallpox eruption over face and body. Unrecognized case, infecting case No. 43.

45	Lowell, . .	Sept. 20,	M.	17	Discrete, .	Ten years ago, .	Ill September 14. Eruption 17th. Eruption in vesicular stage.
46	Waltham, .	Sept. 23,	F.	5	–	Two years ago, .	Diagnosis, impetigo contagiosa.
47	Wareham, .	Sept. 26,	M.	20	–	Six months ago, .	Diagnosis, typhoid fever.
48	Fitchburg, .	Sept. 29,	M.	70	Confluent,	Infancy, . . .	From North Adams September 21. Ill 25th. Eruption 27th. Eruption in vesicular stage.
49	Westfield, .	Oct. 1,	F.	3	–	No, ...	Diagnosis, urticaria.
50	Westfield, .	Oct. 1,	M.	2	–	No, ...	Diagnosis, urticaria.
51	Randolph, .	Oct. 13,	F.	6 months,	–	No, ...	Diagnosis, chicken-pox.

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